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EMBEDDED COMPUTER RESOURCES AND THE DSARC PROCESS - A GUIDEBOOK--ETC(U)
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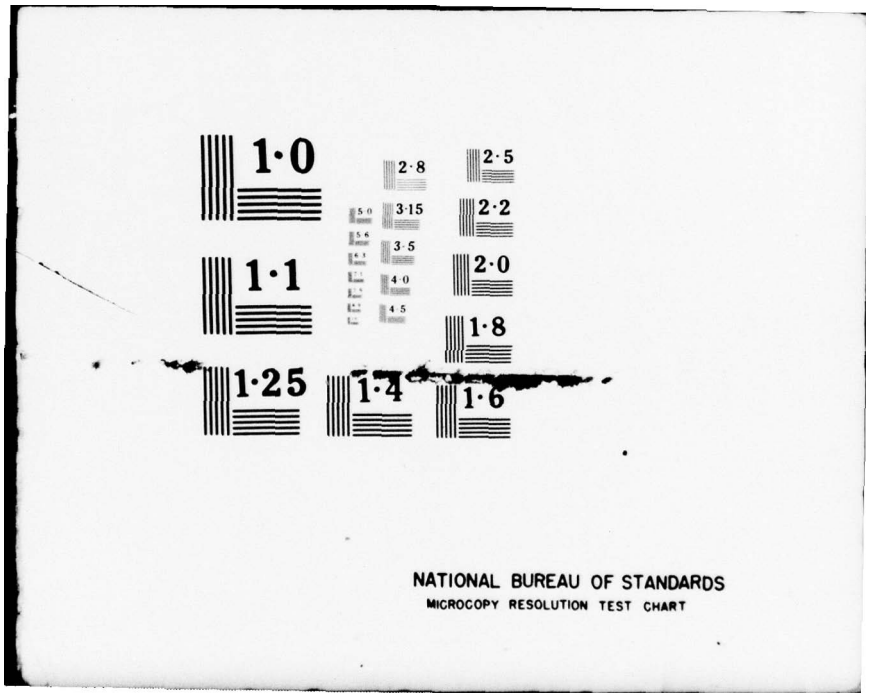
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EMBEDDED COMPUTER RESOURCES AND THE DSARC PROCESS

Introduction

In the Spring of 1975, a major new initiative was undertaken in the area of software management for weapons, communications, command and control, and intelligence systems. Organizational steps which give the proper leverage have been taken; OSD policy direction on the management of computer resources has been issued; impacts are gradually being made on major systems; visibility of software as a major system component and decision parameter is being felt.

In order to hasten the assimilation of sound software management policies, practices, procedures, and technology into the normal system acquisition and review process as practiced by OSD and the Military Departments, a guidebook covering salient embedded computer resource issues in the context of the Defense Systems acquisition Review Council (DSARC) process has been assembled. This guidebook, provided in the attached paper, is organized into the following sections:

Part I	General DSARC Issues (DSARC I,II,III)
Part II	Sensitivity Data and Relationships
Part III	Program Inquiry Questions
Part IV	Software Cost Estimation Guidelines
Part V	List of Reference Documents - Policy, Practice, Procedure

Part I of the guidebook reviews the purpose and scope of each DSARC milestone, and translates this into specific questions and issues appropriate for the computer resource and software product. Each question or issue is followed by the spectrum of responses typically received. Whenever possible, responses were ranked in increasing order of preference enabling the guidebook user to develop his own "figure of merit" as a function of the importance of any issue (or set of issues) to the program under review.

Part II presents quantitative sensitivity data for twenty-four managerial and technical factors which relate directly to development productivity, and hence to cost, schedule, and performance risk. These parametric relationships are useful in assessing and forecasting the implications of management and technical decision options. Part III of the guidebook provides a set of inquiries, which although too detailed for DSARC itself, is a useful tool in assessing the overall "health" of a software development effort at any given point in time. Many of the questions in this part will not have answers early in a program (i.e., prior to or shortly after DSARC I) but as progress is made, a larger percentage of them will indeed be answerable. If at DSARC III, a significant percentage (i.e., greater than 10-15%) remain with vague or non-existent responses, there may be cause for serious concern about the readiness for a favorable production decision. Merely reviewing the responses (or lack thereof) to these inquiries will provide a good sense of development progress and the rate thereof, and will aid in the determination of readiness to proceed into the next major system phase.

Part IV of the guidebook gives an empirically derived relationship for checking and verifying the reasonableness of program manager supplied software cost and size estimates. Part V is a list of the pertinent policy, practice and procedure documents which govern embedded computer resources and the DSARC process. Appendix A contains relevant sections of several documents from Part V.

The material provided in this guidebook is intended to assist OSD staff officers and their counterparts in the Military Departments in preparing for, and conducting meaningful review of an increasingly important component of Defense Systems. It is not intended as a set of inflexible rules which substitute for managerial and technical judgement, and should not be used as such.

The Management Steering Committee - Embedded Computer Resources, and the members thereto are available to assist with questions, comments, and implementation of material contained herein. Appropriate names, locations, and telephone numbers are provided in the Appendix B to this document.

Comments and suggestions on material contained herein should be addressed to Barry C. De Roze, Office of the Secretary of Defense, Room 2A318 of the Pentagon. The appropriate telephone number is (202) 695-0121.

Barry C. De Roze
For the Management Steering Committee -
Embedded Computer Resources

* Annual updates to the material are planned. Comments and suggestions will be held for inclusion in the next edition.

PART I

GENERAL DSARC ISSUES (DSARC I, II, III)

The purpose of this section is to provide guidelines to determine adequacy of computer resource utilization and planning. Questions and typical responses are organized into three sections based on the three major Defense System Acquisiton Review Council (DSARC) meetings. (DSARC meetings are normally required for all weapon systems involving over $75 million in research, development, test and evaluation or over $300 million in production. DSARC I, II, and III meetings are held prior to entering the demonstration and validation phase, the full-scale engineering development phase, and the production and deployment phase respectively and are used as input to the Secretary of Defense who decides if the system should proceed to the next phase.) Embedded computer, i.e. those computers integral to a weapon systems from a design, procurement, and operations viewpoint, will be emphasized rather than general purpose computers that also may be used to provide support for some systems. Note that embedded computers range from small units in airborne systems to large units in ground and ship based command and control systems.

This is not a "how-to-do-it" guide. Instead, it consists of a series of questions that OSD personnel could ask prior to DSARC I, II, and III. After each question are several possible responses that might be given by the Program Manager's staff. When it was possible, the responses were ranked in increasing order of preference. By performing a more thorough review of embedded computer resources, reviewing personnel can help to eliminate many of the problems that exist in recently developed systems utilizing embedded computers.

GENERAL DSARC ISSUES

DSARC I

DSARC II

DSARC III

DSARC I QUESTIONS AND RESPONSES

The DSARC I decision point is reached when competitive exploration of alternative systems concepts has been completed and selected alternatives warrant system demonstration.

DSARC I - General Issues

1. Has the Program Manager's Office been set up and staffed? (If so, answer DSARC II questions on Program Manager's staff.)

   A. No; the program is being handled by a Service laboratory.

   B. No; the program is being handled by a major Service command.

   C. An office has been established but only minimum staff has been obtained.

   D. Yes; DSARC II questions on Program Manager's staff have been answered.

2. What steps are being made to insure software visibility?

   A. All software items will be listed as deliverables.

   B. Cost for software will be a separate cost reporting item.

   C. Software will be put under configuration control early in the development process.

   D. A person on the Program Manager's staff will be the focal point for all software development.

   E. Government/contractor design reviews will be performed for software as well as hardware.

   F. Software risks have been assessed and "software first" demonstrations are planned for all risk areas.

   G. All of the above steps.

3. With what other systems will the system have to interface? What knowledge of system implementation of the external system is required? Is this information available?

   A. The system is completely independent.

B. The system will eventually transmit and receive data from higher headquarters; the higher headquarter's unit has not been designed yet. Information on data formats is required but is not available.

C. The system must interface with an existing external guidance system and a manual override system currently under development. Interfacing information on both systems is available.

4. Will more than one agency or contractor develop software for the system? If so, who will arbitrate disputes among them? Will the groups participate in each other's critical design reviews?

A. The main contractor will have many subcontractors that will develop software. No disputes are expected. Subcontractors will not participate in each other's critical design reviews.

B. One contractor will develop software for the ground-based control system and another will develop software for the weapon itself. Disputes between contractors will be resolved by the Program Manager's staff. Neither contractor will participate in each other's reviews.

C. The main contractor will develop software to be located in the weapon system and a subcontractor will develop software for the weapon support system. The contractor will arbitrate all disputes. Both will attend each other's critical design reviews.

D. Only one contractor will develop software.

5. How will critical design reviews be conducted?

A. The contractor will explain the selected system design to the Program Manager's staff; all questions will be answered. After approval, work will proceed.

B. The contractor will provide technical information one week before design reviews. The Program Manager's staff will study all material before the review meetings. The contractor will present the system design and answer all questions during a full day review. After approval, work will proceed.

C. The contractor will provide pertinent technical information one month before design reviews. During the 1 week review, alternative designs and reasons for the nonselection will be reviewed in detail. If alternative designs that have not been considered previously are uncovered, the critical design review will be rescheduled. After the Program Manager's staff is satisfied that the best design has been selected, approval to proceed will be granted.

DSARC I - Operational Requirements Issues

1. Are the system operational requirements well defined? Have they stabilized? Are they realistic? How can this be proven?

   A. Many requirements will depend on results of further development.

   B. The requirements may not be within the state-of-the-art (this will be determined during demonstration and validation). Requirements are well defined and stabilized; requirements have been quantified and are testable.

   C. The requirements are well defined but have not been frozen.

   D. The requirements are well defined and have stabilized. Attainment of requirements can be easily measured.

2. When and how will a validation of computer resources requirements, including software, be conducted? What are the software areas of greatest risk? How will risk analysis be performed?

   A. Immediately after DSARC II; only proven hardware will be used so no risk analysis will be needed.

   B. Validation will be made during full-scale engineering development. The time to develop efficient input/output modules will be the biggest risk; risk will be lowered by hiring more people.

   C. Validation will be done prior to DSARC II by using competitive preliminary development by two different contractors; the best system design will be chosen based on schedule and costing estimations. The main risk area is computer timing due to the large amount of mathematical processing that will be required. Risk analysis will be performed by qualitatively ranking all major risk areas.

   D. Validation will be made during the demonstration and evaluation phase by using a software-first emulation technique. The time and cost to develop the executive program presents the greatest risk. A decision risk analysis computer program will be used.

3. Which operation requirements are likely to change during development of the system? During system deployment? How will the software accommodate these changes?

   A. Since the system is entirely independent of other systems, the operational requirements will not change.

B. Enemy threats will change. All parameters concerning enemy systems will be located in special memory locations; changing those memory locations will update the system capability.

C. Enemy countermeasures will be developed after the system has been deployed. Software will be modular, allowing easy modification by the software support agency.

D. Equipment with which the weapon system must communicate will change. Software will be written so that only the input and output modules must be changed.

DSARC I - Life Cycle Management Issues

1. Who will provide post development support? Why was this selection made?

   A. Unknown at this time.

   B. The contractor who will develop the system; development costs will be kept to a minimum.

   C. Government personnel; follows support doctrine of the Military Department.

   D. Originally the contractor, later government personnel; this will minimize total life cycle costs.

2. When will the system life cycle support activity and the software life cycle activity be designated?

   A. After DSARC III.

   B. After DSARC II.

   C. Both activities have been designated.

3. Will Operations and Maintenance funds be requested to support contractor activities directed toward providing maintenance capabilities and documentation?

   A. No

   B. Yes

4. How and when will maintenance provisions be specified?

   A. "Appropriate maintenance provisions" will be included in the contract for full-scale engineering development.

B. Maintenance provisions will be part of the development contract; the maintenance contract will include . . . . .

5. How will support requirements be determined?

A. They will be determined by the Program Manager's staff.

B. Support requirements will be determined by discussions with users of similar systems that are already deployed.

C. Requirements will be supplied by the appropriate support agencies, when they are designated.

D. A combination of elements of responses A, B, and C.

6. What computer hardware will be unique? Why can't standard hardware be used and how will replacement parts be obtained?

A. Computer requirements are not known.

B. A unique processor is needed to efficiently utilize a new programming language that has been chosen to minimize program development time. Replacements will be bought sole source from the manufacturer.

C. A unique processor already embedded within the system (e.g. a microprocessor contained in the navigation equipment) will be expanded. Compatable processors can be procured from several manufacturers that sell the processor to the commercial market.

D. New hardware is required because existing processors are not fast enough. All unique parts for the expected life of the system will be purchased at one time shortly after system deployment.

E. No unique computer hardware will be utilized.

DSARC I - Tradeoff Issues

1. What tradeoffs will be made between the embedded computer and other methods of meeting the system requirements?

A. None; operational requirements cannot be meet without the embedded computer.

B. Manpower and support costs required to perform the required task with existing methods and equipment will be compared with the development, manpower, and support costs of the computerized equipment.

C. A simple system requiring a highly skilled operator to evaluate computer results will be compared to an elaborate system to be used by

a less skilled operator. Tradeoffs will be based on development and support costs, including operator training required.

2. How will hardware/software tradeoffs be made?

   A. Hardware will be minimized in order to meet design-to-cost goals.

   B. Maximum use of software will allow greater flexibility for future changes.

   C. Time critical tasks will be done with hardware; all others with software.

   D. Engineers will make tradeoffs during the demonstration and evaluation phase, based on availability of newer hardware, changing needs, etc.

3. How will the processor architecture be determined?

   A. The architecture will be determined by selecting the lowest cost computer.

   B. We will select the architecture that will minimize program development time.

   C. The architecture that will minimize cost of computer and interface electronics will be selected.

   D. The architecture that will minimize time to perform required calculations will be selected.

   E. The architecture that will minimize life cycle costs (including increasing weapon system capabilities after deployment) will be chosen.

4. How will the processor memory capacity be determined?

   A. The maximum memory capacity will be selected.

   B. Memory capacity needs will be extrapolated from similar existing equipment.

   C. The required capacity will be determined, then a fixed percentage will be added for future expansion.

   D. An estimate of how requirements might change will be made, then an estimate of how much additional memory capacity would be required to handle those changes will be made.

5. How will excess memory, processor time and capability needs be determined?

   A. The system with largest memory, fastest processing speed and most capability will be used.

B. They will be extrapolated from similar systems.

C. Modules containing critical timing have been programmed; timing results were used as a basis for estimates.

6. How will the team that wrote the original requirements document be kept for tradeoff studies?

A. A separate team will do the tradeoff studies.

B. The team will be "on call" during the demonstration and validation phase.

C. The team will remain attached to the Program Manager's Office until tradeoffs are made.

DSARC I - Use of Existing Hardware and Software Issues

1. What new technology (computer, sensor, and control) must be used?

A. The sensor to be developed must have an order of magnitude better resolution to detect the anticipated stimulus.

B. The computer must process data faster than can be done with existing computers.

C. Real-time control will require development and implementation of a new control algorithm.

D. None

2. What special tasks must be performed in the demonstration and validation phase to perfect new technologies?

A. It is not known for certain at this time.

B. Special tasks will be determined in joint contractor-user discussions after the demonstration and validation contract has been awarded.

C. (Generalized list of tasks to be performed.)

D. (Detailed list of tasks to be performed.)

3. How much system design can be obtained "off-the-shelf" from previous systems?

A. None; the weapon system being replaced had no embedded computer.

B. Little; the new embedded computer has different architecture and computer word length.

C. A medium amount; the same guidance hardware will be used; however, the method of calculation of guidance parameters is different. The new system will use a similar operating system.

D. A large amount - software is a minor extention of a previously developed system.

4. Which existing operational application and support packages will be utilized? Are the application programs operational on the target computer? If not, what are the major hardware/software differences? To what extent have the contractor's personnel used these packages previously?

A. Similar application programs have been written, but for systems having very different architectures and input/output methods (all applications programs must be rewritten). Since no support software is available, it will have to be written by the contractor.

B. Control modules used in another system will be used as will an extensive library of support software. Application programs will have to be modified due to different word lengths of the original and the target computers. Contractor's personnel have not used these control or software support programs before.

C. No existing operational application programs exist. Support packages such as cross-assemblers and compilers will be used; contractor's personnel are familiar with these packages.

D. Numerical processing modules previously developed for the target computer will be used. Support packages to be utilized were developed by the contractor for a previous system; most contractor personnel have used them.

DSARC I - Possible Future Problem Areas Issues

1. Has preliminary systems analysis been performed? What hardware and/or software problems areas were discovered?

A. No systems analysis was needed or performed.

B. System analysis indicated a possible saturation of available computation time.

C. The interconnection of the many embedded computers within the weapon system may require more man-months than originally estimated.

D. System analysis indicated computer memory needed may require more electrical power than is available.

2. How will the problems of question 1 be handled in the demonstration and validation phase?

   A. Since problems cannot be readily envisioned, solutions will be handled on a case-by-case basis.

   B. A faster computer might be needed.

   C. Extra space might be needed within the weapon for additional memory and power supply.

   D. The single embedded computer should be replaced with several microprocessors, each performing a dedicated function.

3. What critical areas must be resolved during the demonstration and validation phase? How?

   A. Can computing system be made small enough to meet desired size and weight restrictions? Prototype modules and techniques needed for manufacturing will be developed earlier than normal.

   B. Can design-to-cost goals be met? Costs will be considered during all internal engineering reviews.

   C. Can the weapon system be maintained in the field? Limited field testing will be performed before full-scale development to determine maintainability.

4. Do you envision other risky areas? What are your plans to resolve these problems?

   A. Schedules seem optimistic due to state-of-the-art techniques to be utilized; schedules will be monitored closely.

   B. Interfacing of many embedded computers within the weapons system will be required; a common data bus for interconnecting all systems will be specified.

   C. Adequate monitoring of software development; the Program Manager will request assistance from the Service command dealing with software.

   D. Real-time testing of the completed system will be difficult; testing hardware and software will be developed concurrently with the weapon system.

DSARC II QUESTIONS AND RESPONSES

The DSARC II decision point is reached when the demonstration and validation activity has been completed and a recommendation on the preferred systems for full-scale engineering development can be made.

DSARC II - General Issues

1. What are the present problems and the plans for resolving them?

   A. No present problems.

   B. Minor problems only; "they will take care of themselves".

   C. (List of major problems and list of "get well" actions.)

2. How do you know present cost and time estimates are sound?

   A. Contractor's and Program Manager's staff agree estimates are sound.

   B. Estimates were based on a similar system developed for another service several years ago.

   C. All estimates were developed by personnel with past records of accurate estimates.

   D. Cost and time estimates were developed from small program elements that could be accurately estimated.

3. Of the total computer resources to be spent during full-scale engineering development, what percentage will be used for design, for coding, and for testing? What have these percentages been for the contractor in the past?

   A. Design 25 percent, coding 40 percent, testing 35 percent. Past contractor experience was not on systems of comparable complexity.

   B. Design 30 percent, coding 35 percent, testing 35 percent. Past experience was about one-third in each category.

   C. Design 40 percent, coding 20 percent, testing 40 percent. Past experience was design 30 percent, coding 25 percent, testing 45 percent.

DSARC II - Operational Requirements Issues

1. Have the system operational requirements changed since DSARC I? Are they now stabilized?

   A. Requirements change as costs can be calculated; the weapon system would cost too much if it had to meet original requirements.

   B. Minor changes were needed due to new enemy threats; these types of changes are expected to continue throughout system development.

   C. Major changes were made due to availability of improved hardware; requirements have remained stable.

   D. Requirements have not changed.

2. How will the system design be validated prior to implementation?

   A. Design is similar to other systems that performed satisfactorily.

   B. System design followed directly from the embedded computer architecture; any other design would not use the computer efficiently.

   C. Design will be validated by using simulation.

   D. System design will be reviewed by consultants hired specifically for that purpose.

3. How was validation of computer resource requirements, including software, conducted?

   A. Resources were added, as required, until all requirements were implemented; a review of resources showed none could be eliminated.

   B. Computer resources required were the same as those in the weapon system being replaced.

   C. Validation was performed by a special team of contractor personnel.

   D. Validation was performed by a special team within the Program Manager's staff.

4. How was risk analysis performed?

   A. Since only standardized hardware will be used, no risk analysis was required.

B. Risks in software and hardware were estimated after discussing the system with the Service organization that developed similar systems.

C. Risk analysis was performed by consultants hired for this purpose.

5. How will you insure planned computer resources will meet stated operational requirements?

A. Good estimates of resources needed to meet requirements were used.

B. Computer resources have been overspecified; resources not needed immediately will be available for future expansion.

C. Difficult operational requirements have been programmed; additional memory and time exist for remaining simpler requirements.

6. How will future changes to computer hardware and software requirements be made?

A. The system is designed so that no future hardware and software will be required.

B. The Service Headquarters will submit changes in requirements to the embedded computer support facility.

C. The computer support facility will be the focal point for all hardware and software changes; requests for minor changes will come from the field, while requests for major changes will come from the Service Headquarters.

DSARC II - Life Cycle Management Issues

1. Which DSARC I Life Cycle Management questions are still unanswered? When will the answers be known?

A. There are many unanswered questions; they will be answered during full-scale engineering development.

B. The Service Support Agency has not been designated; all other questions have been answered.

C. All questions have been answered.

2. Has a Computer Resources Life Cycle Plan been written? By whom?

A. It has not been written.

B. It was written by the Project Manager's Staff.

C. It was written by consultants (via a separate contract).

D. It was written by the Service support agency.

3. What steps have been planned for the software "turnover" from the contractor to the government?

A. None; the Service support agency is not known.

B. Software turnover will be coordinated during full-scale engineering development.

C. None; the contractor that developed the software will support it.

D. Detailed schedules have been prepared; the Service support agency will provide assistance during critical design reviews.

4. What are the milestones of the Computer Resource Life Cycle Management Plan? What criteria will be used to measure their attainment?

A. Percent project completion and percent of available funds spent.

B. Delivery of documents from the contractor.

C. Delivery of documents from the contractor after a thorough review of draft copies.

5. How will the computer resources be integrated into the total defense system?

A. This problem will be addressed when the capabilities and limitations of the final system have been demonstrated.

B. Once they are fixed, input/output data formats will be given to the other services so their systems can be made compatible.

C. (List of detailed plans to include coordination within the Service and with other Service members, training for operators and maintenance, personnel, logistic support, etc.)

6. How will the overall system quality be determined?

A. The quality of the system will evolve as the system develops.

B. The system will be measured against the original operational requirements in a series of laboratory simulations.

C. The system will be measured against the original operational requirements in field tests.

7. How were personnel requirements for supporting computer resources determined?

   A. The number of people needed to develop the system will be needed to support it.

   B. Fifty percent of the programmers needed for development will be needed for support.

   C. (A reasonable estimation based not only on programmers, but also on analysts, hardware, interfacing and test personnel.)

8. What software is contract deliverable?

   A. Operating programs in object language are the only deliverables.

   B. Operating programs in source language.

   C. Operating programs in source language plus the compiler and/or the assembler used, development flow charts, and other documentation.

   D. The items listed in response C plus the simulation and configuration management software used during development.

DSARC II Tradeoff Issues

1. How were tradeoff decisions made?

   A. Since no changes in operational requirements are expected, hardware was used as much as possible.

   B. Software was used instead of hardware whenever possible so changes can be made easily.

   C. Time-critical subfunctions were implemented in hardware, the remaining subfunctions in software.

   D. Life cycle costs for software and hardware were used to make hardware/software decisions.

2. Did the user team that wrote the original operational requirements assist in cost versus capabilities tradeoff? If not, how were these tradeoffs evaluated?

   A. No; tradeoffs were done by one of the Service laboratories.

   B. No; cost/capabilities tradeoffs were performed by personnel from the Program Manager's Staff.

C. No; tradeoffs were analysed by a team of future users, support personnel, Program Manager personnel, and prime contractor personnel.

D. Yes

DSARC II - Program Manager's Staff Issues

1. What percentage of development costs will be spent on computer-related expenses?

   A. An insignificant amount.

   B. Five percent.

   C. Twenty-five percent

2. How many dedicated program personnel are skilled in computers and software? What percentage of the staff does this represent?

   A. None; zero percent.

   B. Four persons; six percent.

   C. Twenty persons; thirteen percent

3. How many dedicated program personnel have had operational experience in the project application area?

   A. Only a few.

   B. Less than twenty-five percent.

   C. Greater than seventy percent.

4. What plans have been made to obtain computer personnel temporarily from Service laboratories and support activities? From private consulting firms?

   A. No such plans; no computer or software problems are invisioned.

   B. The Program Manager's staff contains sufficient computer personnel to adequately monitor development of all computer hardware and software.

   C. Contracts have been awarded to private consulting firms to check on software costs and schedules submitted by the weapon system contractor.

D. Computer personnel from the Service support agency will review computer system design, coding, and testing to insure they can maintain the software when the system is deployed.

E. Several computer personnel from Service laboratories have been assigned to the Program Manager's staff during the demonstration and validation phase and will remain assigned during most of the full-scale engineering development phase.

5. Does the Project Manager have an experienced system engineer agent responsible for overseeing software systems engineering?

A. No; most software was obtained from a similar system.

B. No; all software design, coding, and testing will be handled by the contractor.

C. No; overseeing of software development is an extra task performed by the chief engineer in charge of the weapon system hardware.

D. Yes; this individual is the focal point for all software development.

6. How will the Program Manager provide for maintenance support requirements? Is there a dedicated Software Operational Support Agency?

A. The contractor was told to consider maintenance during design of the system; the Service software support activity is not known so a dedicated support agent is not required.

B. Personnel from the Service software support activity attend all reviews to be sure maintenance support is adequately considered; no dedicated support agent is required.

C. Maintenance support requirements were determined by reviewing similar systems; the requirements were then incorporated into the contractor's Statement of Work; there is a dedicated staff person acting as software operational support focal point.

DSARC II - Project Control Issues

1. What management procedures will be used to control software development? How will they monitor costing and scheduling?

A. The actual versus projected percentage of programming completed will be compared on a monthly basis for each major computer subprogram; costs will also be compared.

B. Software development will be controlled by means of system requirement and system design reviews and the documentation associated with these reviews.

C. Software development will be controlled by comparing actual to estimated completion dates and actual to estimated development costs for all programming modules in the system.

D. PERT/CPM will be used, with the development of each major software module being an event in the network.

2. What milestones have been chosen for the management plan?

A. All milestones are based on percentages of total programming completed.

B. Milestones consist of receiving written documents.

C. Milestones consist of receiving final copies of selected documents that have been previously reviewed for content, completeness, accuracy, etc.

D. Milestones consist of easily recognized low level events in software development such as freezing of design specifications, passing of operational tests, etc.

3. Will there be any parallel software development efforts? If so, how will they be controlled?

A. A chief programmer will control all teams doing parallel development.

B. Weekly meetings of programming team leaders will be held to improve communications among teams doing parallel development.

C. Programming standards will state which parameters will be passed to modules developed by different teams; storage of shared data will also be covered in standards.

D. Relatively little software is needed; no parallel efforts are planned.

4. How will interface control be handled?

A. External hardware to be used has not been determined; software will be modified when hardware specificatons are available.

B. The weapon system will contain many external devices; interfacing to each device will be handled on a case by case basis.

C. An Interface Design Specification will be provided by the contractor at start of full-scale engineering development; it will contain complete specificatons of all interfaces.

D. Interfacing information for all Government Furnished Equipment has been provided to the contractor; the contractor will handle all internal interfacing.

DSARC II - Development Contract Issues

1. Will the acquisition take place in accordance with Public Law 89-306? Why or why not?

   A. It will depend on how the contractor desires to acquire the computing system.

   B. The computer will not be acquired in accordance with PL 89-306 because it is not an "off-the-shelf" system.

   C. The ground support computer will be acquired under PL 89-306; the airborne computer will not; determination was based on where the computer will be located.

   D. The computers were not acquired in accordance with PL 89-306 because they are embedded within the weapon system.

2. Which type of contract will be employed for the software?

   A. Software does not have a separate contract but is part of the hardware contract.

   B. Fixed cost contract.

   C. Cost plus fixed fee contract.

   D. Cost plus fixed fee with incentative for early delivery.

3. How will the contractor be tasked for software items?

   A. All software is treated as a single configuration item.

   B. Operational, developmental, and system support software are each handled as separate configuration items.

   C. The contractor will develop a list of software items which will be reviewed by the Program Manager prior to tasking for software items.

   D. Separate software consultants will determine the software tasks that must be performed.

4. What will be the software-related contractor incentives?

   A. There will be none.

   B. Incentives will be given for early completion.

   C. A percentage of difference of estimated and actual software development cost will be paid to contractor.

5. How will "negative software incentives" (minimizing hardware at the expense of software) be handled?

   A. After development, software will be supported by the contractor on a fixed fee basis.

   B. Separate consultants will determine whether software/hardware trade-offs have been made in the proper manner.

   C. The contractor incentive fee will be based on life cycle costs that include software maintenance.

   D. There are separate contracts and incentives for software and hardware.

6. Is all software listed as configuration item(s)? Which software is not deliverable?

   A. No; the contractor implemented several functions with microprocessors rather than with hard-wired logic; this microprocessor software is not included in the contract.

   B. No; development software was previously developed by the contractor at his own expense and will not be delivered with the operational software.

   C. Yes.

7. Is all support software listed as deliverable? Is any proprietary? If so, how will this behandled?

   A. Software will be maintained by the contractor so there are no proprietary software problems.

   B. A proprietary high-level language preprocessor will be used during software development; output of this preprocessor is in acceptable form for required documentation.

   C. Arrangements have been made with the contractor to lease proprietary software when it is needed for software support and maintenance.

   D. All software is listed as deliverable.

DSARC II - Testing Issues

1. When will the system and program designs be frozen?

   A. Not known; the desired capabilities of the weapons system are continually changing.

   B. Near the end of full-scale engineering development.

C. System design is now frozen, program design will be frozen early in full-scale engineering development.

D. System and program designs have been frozen except for certain key modules which are expected to change (due to changing enemy threats) during full-scale engineering development.

E. All system and program designs have been frozen.

2. How will software testing be performed?

A. Personnel developing the coding will test it as it is being developed; each programmer will generate his own test data.

B. Testing will be performed by a different group than the one that developed the programs; the testing group will generate the test data based on the system functional requirements.

C. The contractor will develop a test plan for testing of all software; this plan will be reviewed by Program Manager's staff for adequacy.

D. Software testing plans were developed by the contractor during the demonstration and validation phase; several modules that will be used in the delivered system have been tested in accordance with this plan.

3. How will you insure the test data is representative of the total range of data and conditions that the system might encounter?

A. Program test data was developed for all "worst cases".

B. Hot-beds are to be used to simulate conditions that will exist in the actual environment, including noise.

C. Programs were monitored to check that all code was used during testing; when necessary, special data was created to test all code.

D. In addition to laboratory testing, the system was given preliminary testing in the field.

4. Is there a software module test plan and a software module test procedure?

A. No; since there is relatively little software in the system, formal test plans and procedures are not required.

B. No; the contractor policy on software testing was utilized.

C. Yes; plans were developed by the contractor early in the demonstration and evaluation phase and were approved by the Program Manager.

D. Yes; plans were developed by Program Manager consultants working with the contractor.

5. How will testing be used to clearly identify deficiencies as software or hardware related? How will the determination of whether other errors are caused by hardware or software be made?

A. Software will be fully tested using software emulation; any errors discovered later must be due to hardware.

B. Software is being developed by engineers; their backgrounds will enable them to differentiate between hardware and software errors.

C. In-circuit emulators will be used to record the sequence of events leading up to errors; trace back will determine source of errors.

D. Most errors will be discovered using hot-bed testing; conditions causing errors will be duplicated until a determination of the type of error can be dtermined.

6. Are "hot-beds" required to adequately test software? Will they become government property after testing is complete? If not, does the government have equivalent integration and testing facilities available?

A. No; software can be tested more cost effectively using software emulation.

B. Yes; hot-beds will not become government property since they will not be needed after full-scale engineering development.

C. Yes; hot-beds will remain at the contractor's site since he will provide software updating and maintenance.

D. Yes; hot-beds are to remain contractor's property; the government has equivalent facilities.

E. Yes; hot-beds are listed as contract deliverable items.

7. How will modules be interfaced with one another? How will these interfaces be tested?

A. All parameters used by more than one program module are located in dedicated memory locations available to all modules; no interfacing between modules is required.

B. The software will be developed "top down" so interfacing will not be a problem.

C. A special software team will interface and test program modules developed by other programmers.

D. Interface specifications are developed before programming begins; interfaces are tested using especially generated test data.

8. What critical questions and areas of risk still need resolving by testing? What are the test plans and milestones for resolving these problems?

A. Only typical cases have been used for testing; there may not be enough processing speed to perform necessary calculations during worse cases; test plans have been prepared to determine and to test the worse case.

B. A new computation algorithm for guidance has been developed based on the design plan for a new transducer; since the new transducer has not been delivered, the software cannot be fully tested; test plans with milestones have been prepared.

C. Some major modules may have to be increased in size to allow for detection of errors in input signals; the increase in memory may require more physical space for the computer; test plans include testing of revised modules, with milestones for determining whether or not more space will be required.

D. All testing has been performed under controlled conditions in the laboratory so performance in the field is unknown; test plans include scheduled tests in the operating environment with milestones based on successful completion of the tests.

9. How will test related documentation be maintained to allow repeatability of tests?

A. Individual programmers develop and test their own modules; all test-related information is kept by them.

B. All testing is done by a separate section which maintains all testing documentation; documentation on testing will not be given to the government under the existing contract.

C. All data concerning tests will be recorded in contractor's laboratory notebooks; these notebooks will be available from the contractor as required.

D. Test-related documentation is listed as a contract deliverable item.

DSARC II - Software Reliability and Maintainability Issues

1. Will one of the high order languages in DoD Instruction 5000.31 be used for programming? If not, why not? What percentage of the software will ultimately be written in assembly language?

A. All programming must be written in assembly language due to limited memory and processing time available.

B. Many assembly language routines from previously developed systems will be utilized; the remaining coding will have to be in assembly language also.

C. FORTRAN will be used for all non-time-critical programming modules; 60 percent of the software will be in assembly language.

D. All programming will be in JOVIAL, one of the approved languages.

2. How will you insure the software architecture will be modular?

A. The development contract states all software must be modular.

B. Each module is checked by a review team to insure modularity and good programming practices have been followed.

C. Each module is limited to 50 lines by the editing program that stores programs being developed.

3. How will you insure that "top-down" software development methodology and that structured programming will be used?

A. All programmers are told to use these methods.

B. Both techniques are required in the contractor's programming standards manuals.

C. Both are part of contractor's normal method of programming.

D. Consultants working for the Program Manager have been checking this during milestone review meetings.

4. What programming standards and conventions will be used? How will they be enforced?

A. Each programming team develops its own standards based on what is most efficient for the team members; the team leader is in charge of enforcement.

B. The contractor's normal programming standards and conventions will be utilized; enforcement will be his responsibility.

C. Programming standards and conventions were stated in the original Request for Proposals; adherence to standards will be checked periodically by Program Manager's staff.

D. Completion of the programming standards and conventions manual was a milestone in the computer resource life cycle management plan; all coding will be reviewed by the software life cycle support activity to insure standards and conventions were followed.

E. Standards and conventions were developed by independent consultants working with the contractor; all programs are checked by the computer systems that store the programs being developed.

5. When will the Data Item Index be prepared and how will it be updated? How will you insure the documentation will be adequate for life cycle maintenance?

   A. Since the software programs are small, no Data Item Index is required; likewise adequate documentation will not be a problem.

   B. Since all programming is modular, data can be named differently in each module and a Data Item Index is not needed; documentation will be reviewed for adequacy by the software life cycle support agency.

   C. The Data Item Index will be prepared near the end of full-scale engineering development when all parameters are known; documentation will be checked during all Program Manager reviews.

   D. The Data Item Index has been prepared and is being updated as parameters are added, deleted, and modified; Program Manager consultants will review documentation during full-scale engineering development.

6. Which automatic debugging tools will be used during program development?

   A. None are required because the program is very small.

   B. A debugging package will be provided by the computer vendor to run on his computer.

   C. An in-circuit emulator will be used.

   D. Extensive software emulation on a large-scale computer will be used for debugging.

7. How will error data be collected and analyzed?

   A. Since the programming team is small, informal discussion between programmers will be used.

   B. Program Change Request forms contain a block to indicate why the change was needed; this information is used by the lead programmer to determine causes of errors.

   C. Each update of a program under configuration management must contain the reason for the revision; if the revision is due to an error, the type of error must be given; information on errors is automatically analyzed by the computer.

D. Error data is collected on an Error Report form which is forwarded to the Service's software support group; the support group analyzed the data and prepares Service-wide analysis.

8. How will the software be integrated with the hardware during full-scale engineering development?

   A. After the software is tested using simulation, it will be put on computing hardware that is being developed.

   B. Integration of hardware and software will be done using "hot-beds" that will provide real-time signals to the sensor system and will monitor all output signals.

   C. All software development is being done on computing hardware to be used in the weapon system (the computer being used in an off-the-shelf unit); no separate software integration will be required.

9. How will software be documented as it proceedes from concept to design to the final operational system?

   A. Programmers will keep their own informal documentation until the end of full-scale engineering development, when formal documentation will be prepared.

   B. Software documentation will consist of the System Specification, the Development Specification, and the Product Specification.

   C. Documentation will include the System, Development, and Product Specifications and the Development Test and Evaluation Test Plans and Reports.

10. How will the software be supported in the field? What hardware and software will be needed for the support base? How will it be procured?

   A. Software will be under a one year contractor warranty; all bugs will be out of the system by then so software support will no longer be needed.

   B. Software will be supported by the designated software support activity; since they are already supporting similar systems, they should have the required hardware and software needed to support another system.

   C. The contractor will support all software via a separate contract after system deployment; the contractor already has all required support base hardware and software.

   D. Software will be supported by the previously selected agency; "hot-beds" will be procured with the system, but proprietary software to support the system will have to be leased from the contractor.

11. How will you insure accuracy of coding to available listings?

A. Each programmer is responsible for destroying all old listings when coding is changed.

B. New listings are printed from the source coding as the first step in making any program change.

C. The listings for each program are kept in a special notebook which is updated after every change.

D. All programs will be in a programming library; all changes must be made through the librarian who will update listings.

DSARC II - Miscellaneous

1. What has the contractor done of a similar nature in the past? What were his successes and failures? What is he doing to eliminate past problem areas?

A. Most of the contractor's experience has been in the hardware development areas, with software development being limited to much smaller systems than the current one; past success rate has been excellent; he has hired many new "software engineers" for this project.

B. The contractor has developed software for many weapons systems of similar complexity; the majority of past systems had schedule slippages and cost overruns, mainly due to changing requirements; the contractor has developed a computerized system to link requirements to coding within program modules.

C. The contractor has developed many systems of similar complexity but this is his first major DoD project; past projects have been very successful; management methods have improved during the past several years.

D. The contractor has developed several large-scale systems previously; the major problem in these systems was the support of delivered software due to inadequate program documentation; programming and documentation standards have been and will continue to be closely monitored.

2. What problems must be solved prior to DSARC III that have not already been discussed? What is your plan to solve them?

A. Finding trained software engineering personnel for the Program Manager's staff; assistance will be provided by Service support agencies and nongovernment consultants until personnel with the right qualifications can be found and/or trained.

DSARC III QUESTIONS AND RESPONSES

The DSARC III decision point is reached when the production recommendation for the system can be made.

DSARC III - General Issues

1. Are the original operational requirements still valid? How can this be proven?

   A. No; operational requirements are constantly changing due to changes in enemy capabilities.

   B. No; requirements were modified during full-scale engineering development as a result of cost versus capabilities analysis.

   C. Yes; the service has not changed them since the original operational requirements were determined.

   D. Yes; the Program Manager has quarterly meetings with the heads of organizations that will be using the system.

DSARC III - Present Status Issues

1. What are the results of the latest series of operational tests (on the entire weapon system)? Where are the current tests in relationship to the overall test plan?

   A. Major subelements of the system have been tested, but the system has not been tested as a whole because all required software has not been produced. The current test plan is about half completed.

   B. Testing has been proceeding well except for a major malfunction that occurred several tests ago. The reason for the failure could not be determined; a duplicate test was run satisfactorily. The original plan requiring additonal testing was changed due to limitation of funds.

   C. The entire system has worked satisfactorily during the latest tests. Overall tests will be completed after the first few systems produced using normal factory production methods are tested in the field.

D. Testing has indicated that the system is ready for production; no need for system modifications was discovered during testing. Testing has been completed.

2. What impact will the need for subsystem changes discovered during testing and evaluation of the overall weapon system have on embedded computer hardware and software?

   A. Operator reaction time was lower than anticipated; the embedded computer software will have to be modified so the amount of operator interaction is reduced.

   B. Additional cooling required by another subsystem will reduce the amount of cooling available for the embedded computer; the effect of the reduced cooling on computer reliability is not known.

   C. The modifying of subsystems during testing and evaluation created the need for many software "patches"; these patches have been made and tested.

3. Are any software modules incomplete? Which modules and associated hardware are involved? What is the extent of incompleteness and the schedule for completion?

   A. Approximatley half of the software modules have been written and fully tested. Modules dealing with calculating parameters for the guidance modules from sensor inputs have not been completed; these modules are scheduled to be coded and tested during the next six months.

   B. All modules were coded, but testing indicated a faster processor is required. The new processor selected has a different instruction set so some recoding will be necessary; recoding and testing will require three months.

   C. Several guidance modules are about 90 percent completed; they should be completed within the next several months.

   D. All software is complete; the software staff has been reduced to a few programmers to correct any coding found to contain errors during future field testing.

4. What is the profile of the last three months of Discrepancy forms and Software Change Requests? How many discrepancies are still to be corrected? How is the error data collected and analyzed?

   A. The number of software changes requested has remained constant at a high level due to continual changes in requirements. Many errors had not been corrected. Error data is analyzed by individual programmers who made the errors.

B. The number of discrepancies discovered and software changes requested has increased recently due to the integration of many software modules into the total system. Most discrepancies have been corrected. Error data is forwarded to the Service headquarters for analysis.

C. The number of required software changes needed recently increased substantially due to more modules being put under configuration management. Most discrepancies have been corrected; error data is analyzed by the lead programmer.

D. The number of software corrections has been steadily decreasing. All known errors have been corrected. Error data is collected and analyzed by a separate branch that tests program modules.

5. How much of the recent software change activity has been due to program errors and how much has been due to change in requirements? Were changes in requirements due to increased or decreased requirement? Who has the authority to change software requirements?

A. Approximately 60 percent was due to increased requirements. The Program Manager can change software requirements.

B. Approximately 20 percent was due to decreased requirements (due to insufficient memory to fulfill all original requirements). The Service headquarters must approve all software requirement changes.

C. All recent software changes have been due to program errors. Software requirements have been frozen and can only be changed by the Service headquarters.

6. How has delivered code been verified to conform to original software design? Who prepared test data for the verification? How has delivered code been shown to satisfy original operational requirements?

A. The original software design was modular and developed in a "top-down" fashion and thus verification was automatic. Test data for verification was prepared by a special consulting group hired by the Program Manager for that purpose. The code is running without errors so original operational requirements must have been met.

B. Individual programmers were responsible for conforming to the software design and for preparing their own test data. Delivered code was used in operational tests that satisfied original operational requirements.

C. A separate testing branch prepared all test data and verified that delivered code conforms to the original test design. Computer workload equivalent to the worst case operational requirements was used to test the software.

D. In the original software design the major programs for each operational requirement were identified; during full-scale engineering development each major program was broken down into many program modules which conformed to the original design. Test data for verification was developed by the system designers during software design.

7. How was hardware/software integration and validation performed?

A. Software was developed on large scale computers; after testing, the entire software package was transferred to the target computer and retested.

B. As individual modules were developed and tested on a large scale computer, they were transferred to the actual hardware and retested.

C. Since very little software was required, it was developed on the computer hardware that will be used in the weapons system.

8. What is the accuracy of coding to available listings? How can this be demonstrated?

A. Listings are not normally kept. New listings are produced by the program librarian whenever needed.

B. Very good; verified by checking programmer's deck with his listing.

C. Excellent; this can be verified by comparing listing kept in program development notebooks with printed listings obtained from program librarian.

D. Excellent; the program librarian puts a copy of each updated listing in the appropriate program workbook whenever a program is modified.

DSARC III - Life Cycle Management Issues

1. Are any life cycle management questions from DSARC II still unanswered? Why?

A. The software support agency has not been selected yet.

B. Personnel requirements for supporting the software have not been determined because the amount of software to be revised annually (due to errors and changing enemy threats) has not been determined.

C. There are no unanswered questions.

2. Is the computer resource life cycle management plan on schedule? If not, what impact will this have on the entire weapon system during production and deployment?

A. No; the software has not been fully tested. Systems will be assembled with Read Only Memory hardware that contain untested programs. These memory elements will be replaced if software errors are discovered after production.

B. No; the schedule of events leading to government software support has slipped due to inadequate software documentation. No effect on production and deployment is envisioned.

C. No; the computer resource life cycle management plan has not been fully developed. This should have no effect on production and deployment.

D. The plan is on schedule.

3. When will the software "turnover" from the contractor to the government take place? What steps have to take place before the turnover? Is the software life cycle support activity prepared for the turnover?

A. Once software is completed, no revisions are planned. No software turnover will be required.

B. [illegible]r will take place after the two year warranty period expires. [illegible] main steps in the turnover must include transfer of all source coding, documentation, support software, and test bed equipment. When the time comes for turnover, the activity will be prepared.

C. Software will be supported in the field by the contractor, first under warranty and then by a separate contract.

D. Turnover will take place after field testing of the first production models (assistance in removing software bugs will be provided by the contractor for one year after turnover). The main items to be completed before turnover include hiring of additional personnel, providing required software training, checking final program documentation, and leasing of proprietory support software from the contractor.

4. Who will provide software support during deployment of the system? What items will be required in the support base? How will future modifications to baseline software be handled?

A. The contractor will correct all errors discovered during the one year warranty period. No other software support should be required after that time.

B. The contractor will provide continuing support through a separate support contract. He already has the needed support base. Future modification will be made on an annual basis.

C. The software life cycle support agency selected prior to DSARC II will provide long term support. Items that must be included in the support base are an assembler (or cross-assembler), a compiler, an editor, a

loader, and debugging programs. Future modificatons will be made when requested by the users of the weapon systems.

D. Software will be supported by the Service software support agency. Items required include trained computer analysts and programmers, source coding and documentation, large-scale computer with support software, and equipment to provide appropriate input signals and record output signals. Requests for software modification will be analyzed quarterly to determine when changes will be made.

5. What will be the impact of anticipated software improvements? What are the anticipated improvements and which areas of the system will be involved?

A. No software improvements are anticipated; however, some coding may have to be modified in the data conditioning modules if sensors are improved.

B. During the estimated four year production run, software will be simplified when a more powerful microprocessor replaces the one now in the system; the simplified software will require less memory.

C. Improved error detection software will be developed and added to the system during the first annual software revision; changing of some Read Only Memories will be required.

D. Modular programming techniques were utilized to make improving software straight forward; no major impact due to software improvement is expected.

6. What is the general logic flow for the system? How would government personnel go from the general flow chart to the source coding? Is a Data Item Index a deliverable item?

A. The general logic flow is described in the Type II Specifications. Each block in the general flow chart represents from 50 to 4,000 lines of program coding. Associated with each block are the names of the subprograms that contain the source coding. A Data Item Index was not used during program development, because one was not required in the original contract.

B. General logic flow is described in the system documentation. Each element in the general flow chart is a subroutine which contains the source coding. A Data Item Index is a deliverable item.

C. The general logic flow diagram is shown in the first section of the systems specification documentation. Since the software was developed using the "top-down" method, the desired module in the general logic flow diagram leads to a lower level module which leads to a still lower one until the desired source coding is located. A Data Item Index has been developed and will be delivered to the software support agency.

7. How is the software compatible with operation/logistics concepts?

   A. All software was written in a Higher Order Language to make software modification less expensive over the life cycle of the weapons system.

   B. Software will be stored in Read Only Memory chips which will be distributed via normal logistics channels.

DSARC III - Miscellaneous

1. Under what conditions will a formal operational test and evaluation be required for major computer hardware and/or software changes made after deployment of the weapon system? How will it be funded?

   A. No major computer hardware or software changes are expected.

   B. Several years after deployment, the embedded computer unique to the weapon system will be replaced by a military standard computer with a standard executive software package; a formal operational test and evaluation will be required. Funding will be provided by the office managing the conversion to the military standard computer.

   C. A formal operational test and evaluation will be required if any change requires more than one-third of the software to be rewritten. Funds for testing will be included in the request for additional funds needed to implement the change.

PART II
SENSITIVITY DATA AND RELATIONSHIPS
PRODUCTIVITY INFLUENCE FACTORS

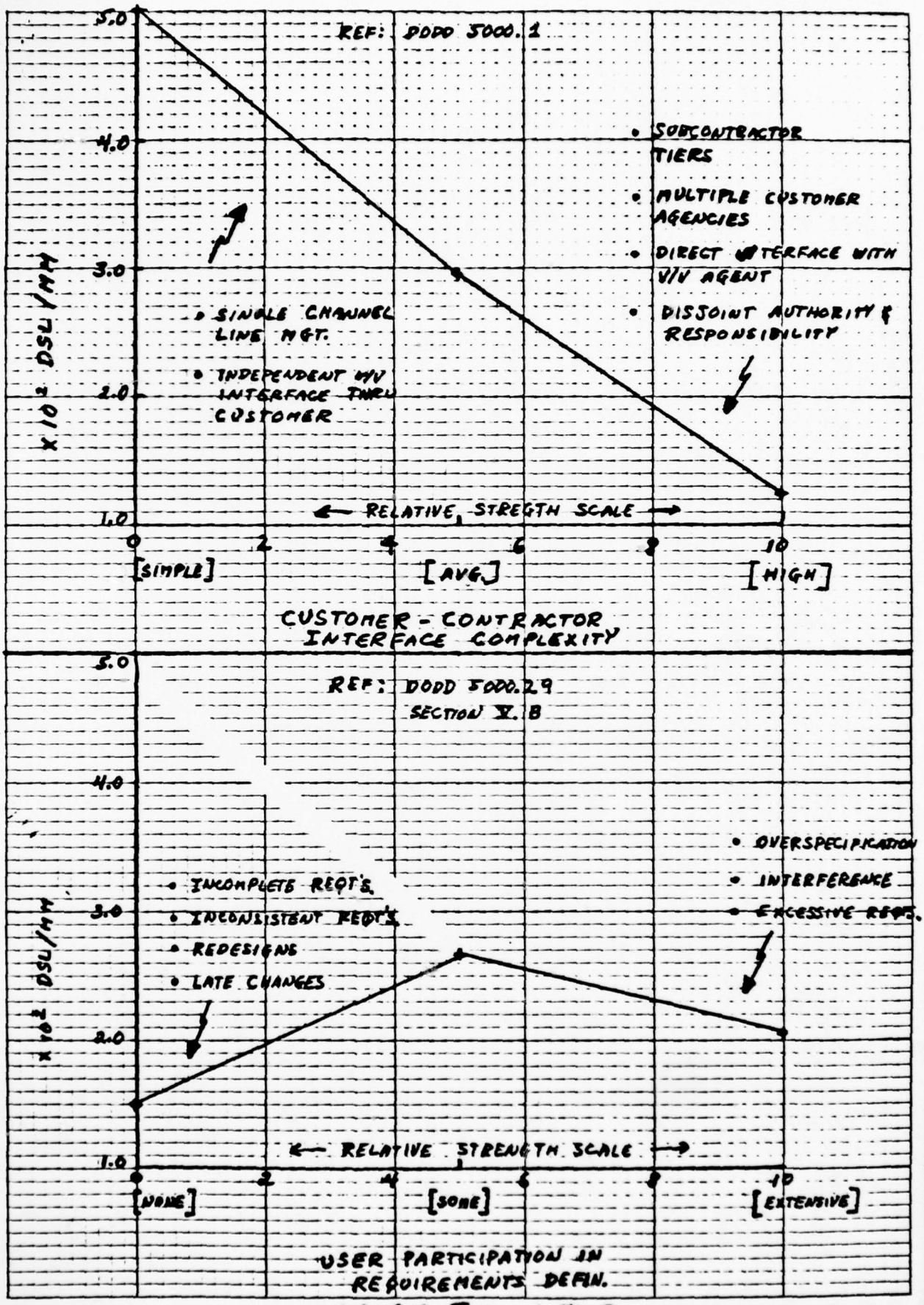
- Customer - Contractor Interface Complexity
- User Participation in Requirements Definition
- Program Design Changes
- Customer Experience with Application Area
- Contractor Personnel Experience and Qualification
- Programmer Participation in Functional Design
- Previous Experience with Operational Computer
- Previous Experience with Programming Language
- High Order Language Versus Assembly Language
- Previous Experience with Bigger Programs
- Classified Environment Effect
- Staff Size (Efficiency and Communication Paths)
- Structured Programming Effect
- Design/Code Inspection Effect
- Top Down Development Effect
- Chief Programmer Team Effect
- Effect of Developed Code Complexity
- Percentage of Deliverable Code
- Storage Constraint Impact
- Timing Constraint Impact
- Real Time Impact
- Non-Mathematical Code Impact
- Data Base Dispersion
- High Order Languages on Small Dedicated Processors (large production volume) - Break Even Cost Criteria

Figures II-1 through II-25 describe the parametric relationship between twenty-five "influence factors" characteristic of a software development effort and a relative productivity index.

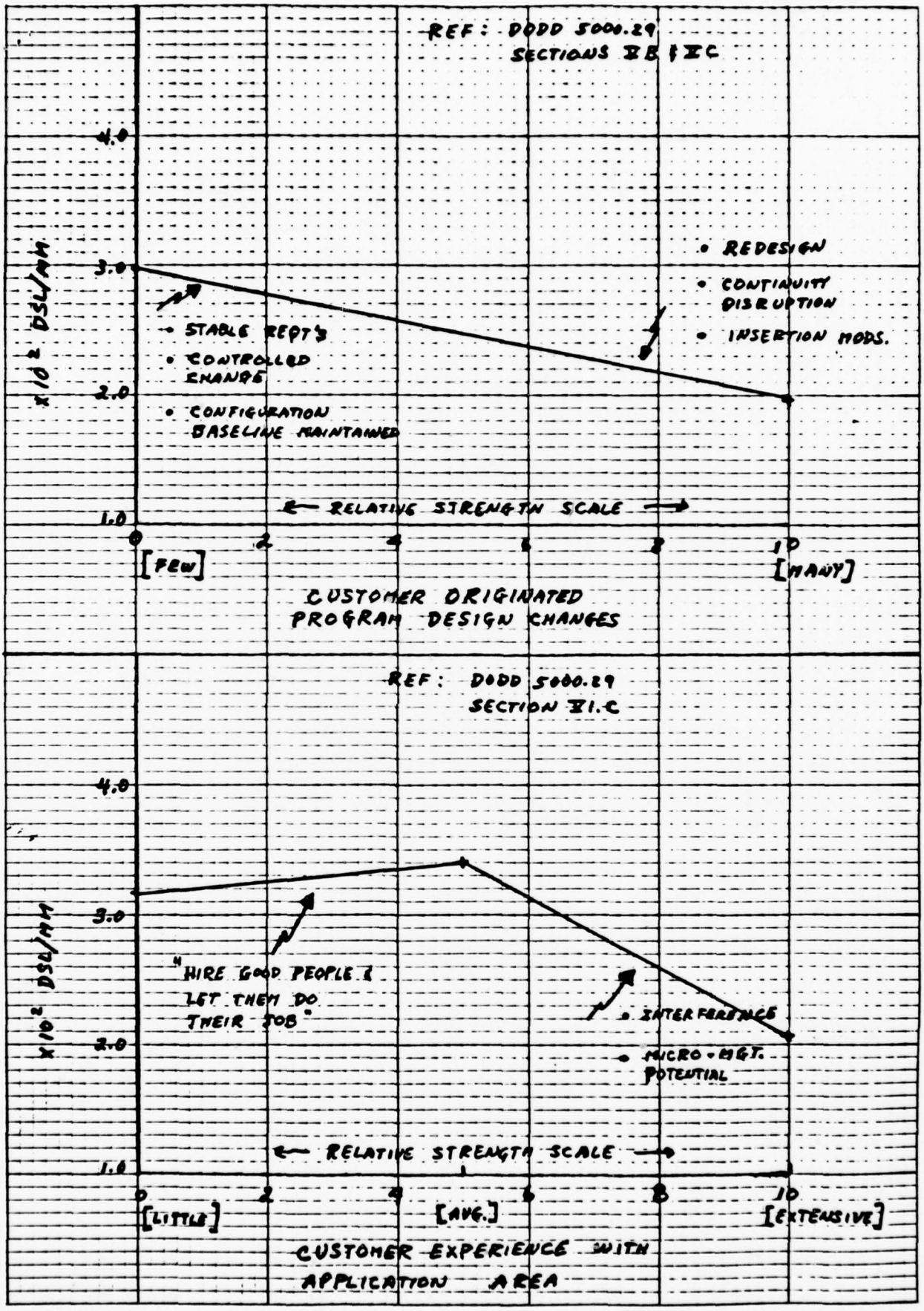
As used in the figures, productivity is measured in terms of Delivered Source Lines of Code per Man-Month. This measure thus includes the functional activities of design, development and testing, in addition to coding. In using the productivity index, it should be assumed that the quality of the final product (i.e., delivered code) is fixed at a median level of three faults per 1000 lines of source code.

Developments which attempt to stress the productivity index (i.e., force higher productivity without appropriate shift on the influence factor abcissa) will probably experience a quality distortion of the three fault/1000 line median. Should this occur, Figure II-26 illustrates the cost impact of detecting and correcting a fault after delivery.

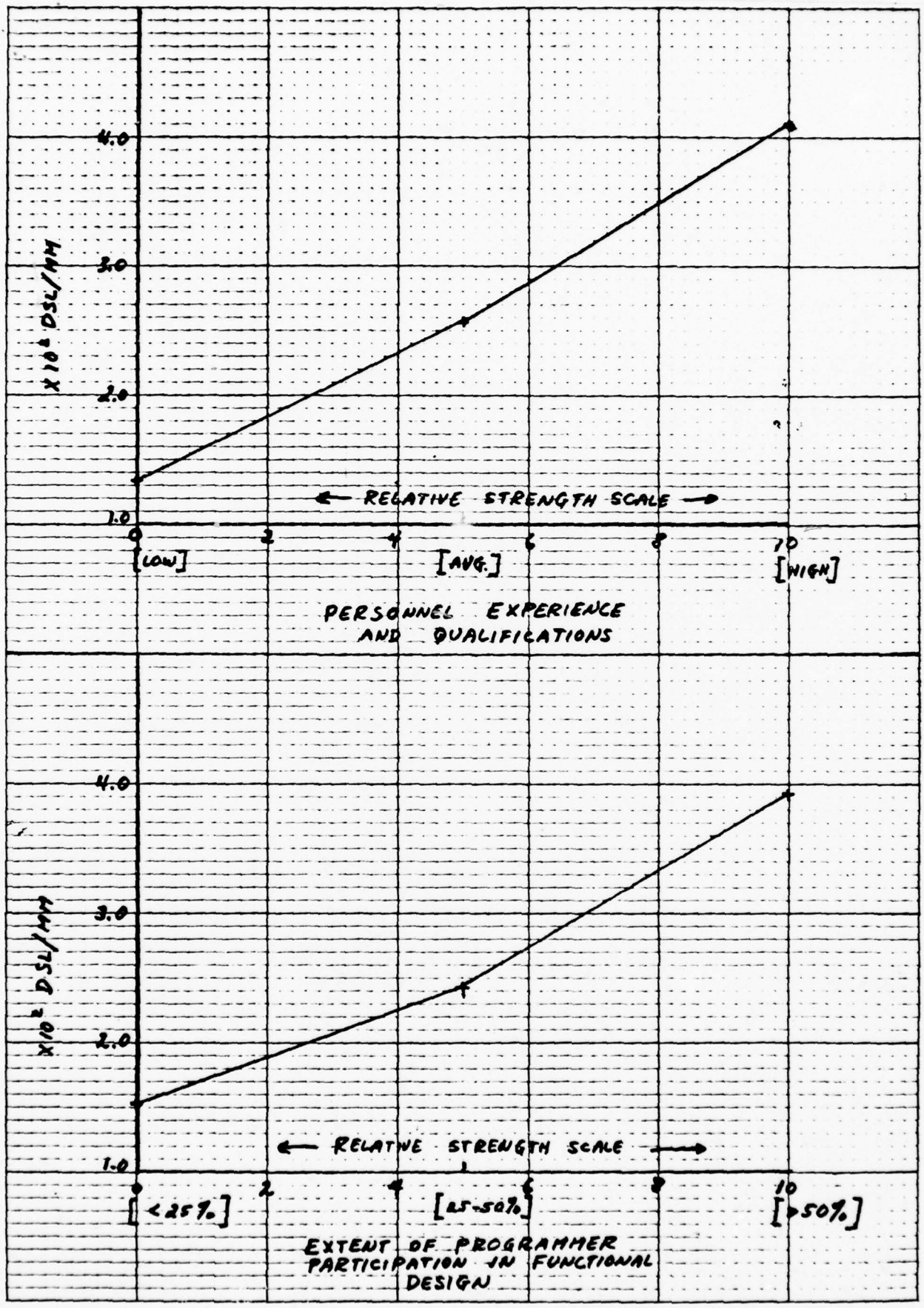
Of course, many other factors prevading the software design, development, implementation and test environment affect the contractor productivity, and hence the probability of meeting realistically set schedule, cost, and quality requirements. However strong ones intuitive feeling, though, there is little empirical evidence in hand to date that would suggest these other factors to have more than a secondary influence on productivity, schedule, cost, or quality.



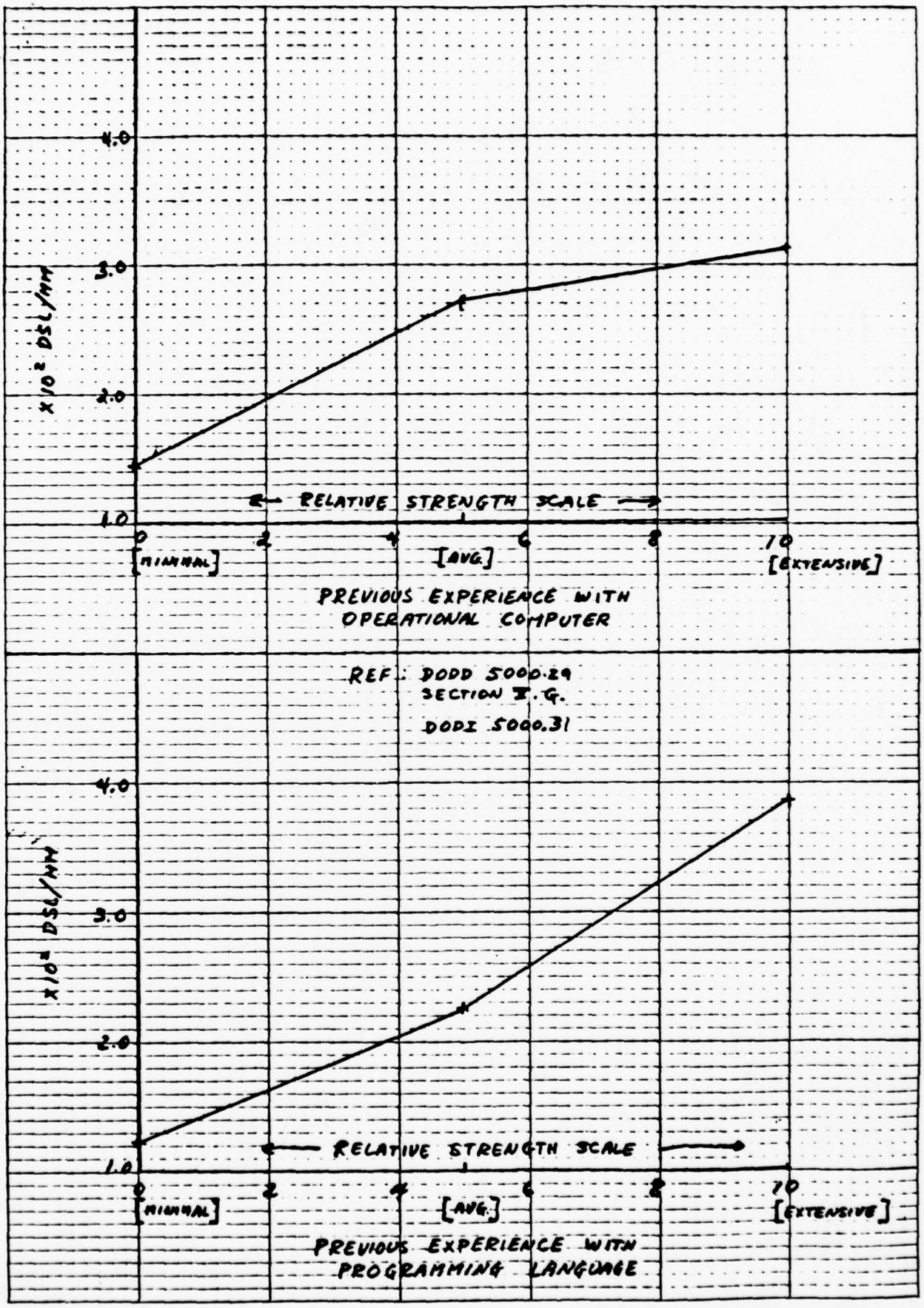
FIGURES II-1 & II-2



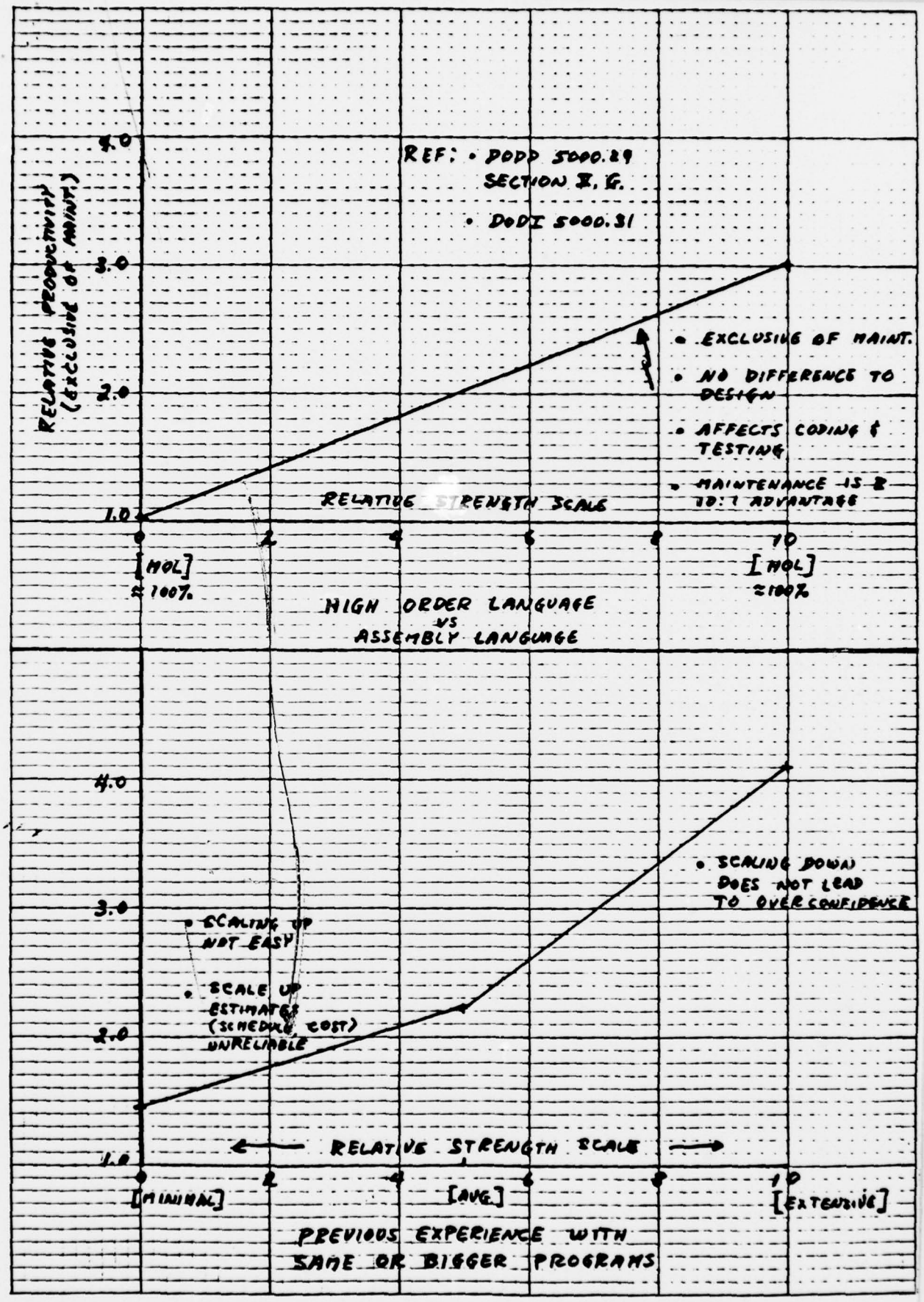
FIGURES II-3 & II-4



FIGURES II-5 & II-6



FIGURES II-7 & II-8



FIGURES II-9 & II-10

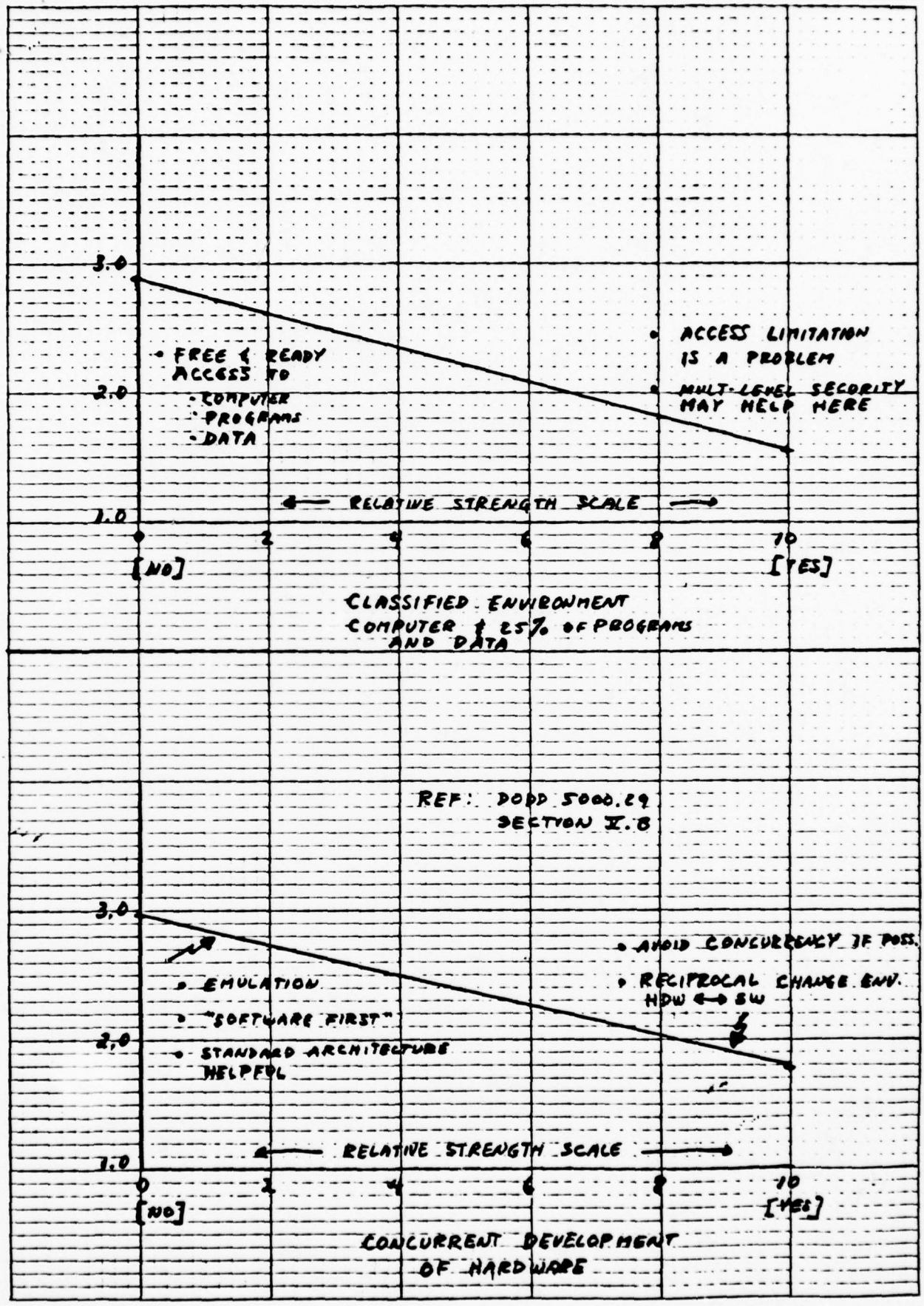
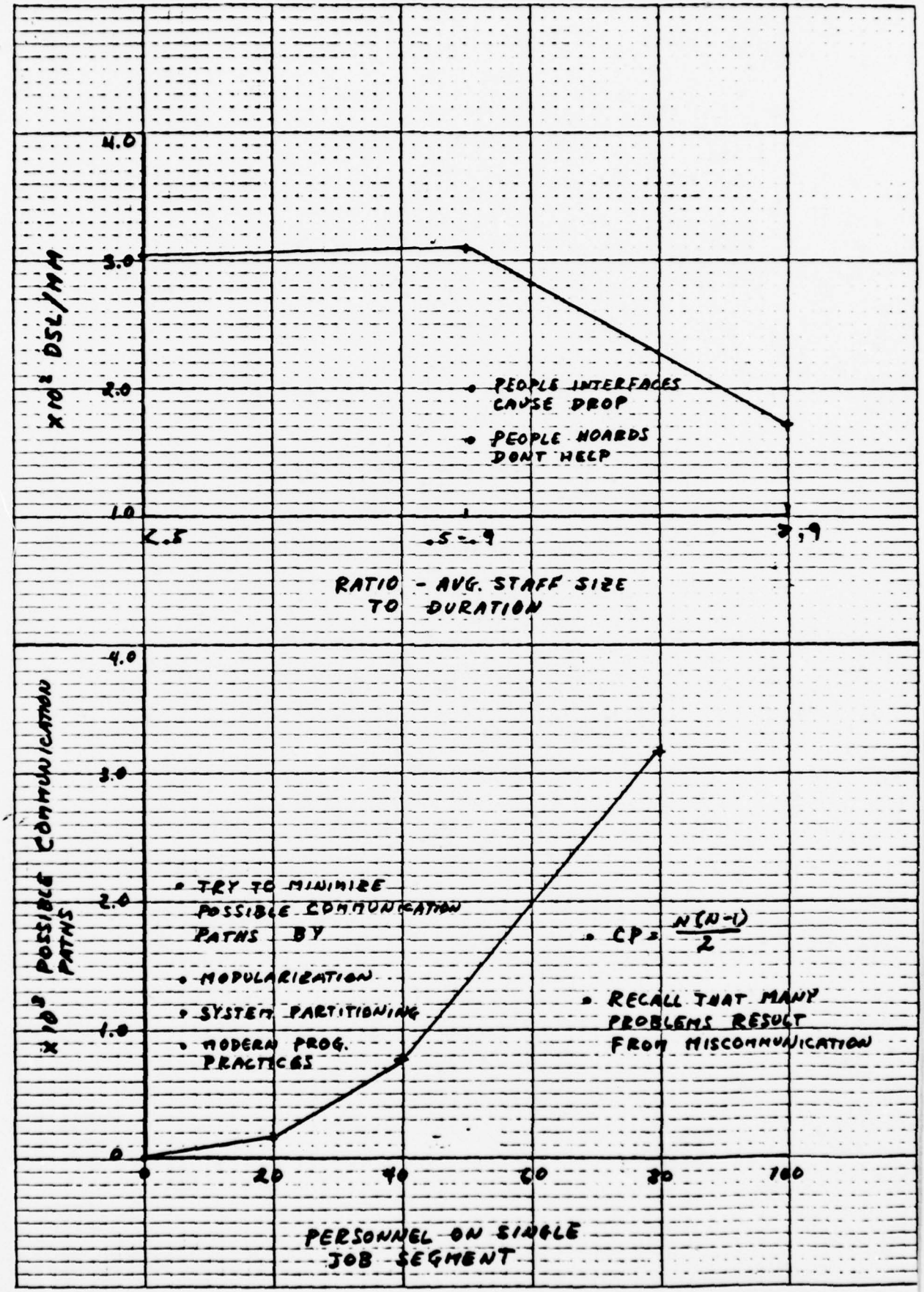
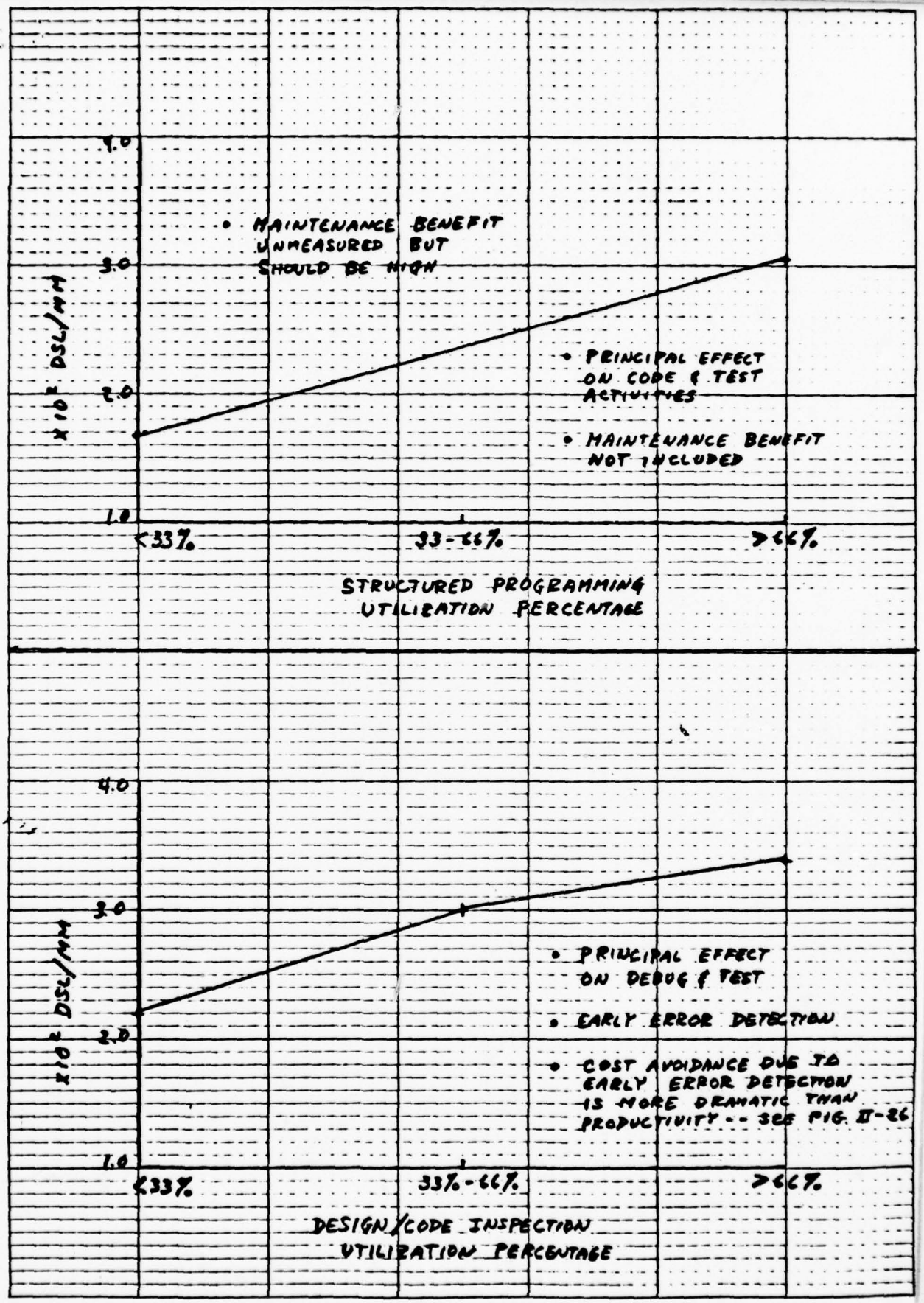


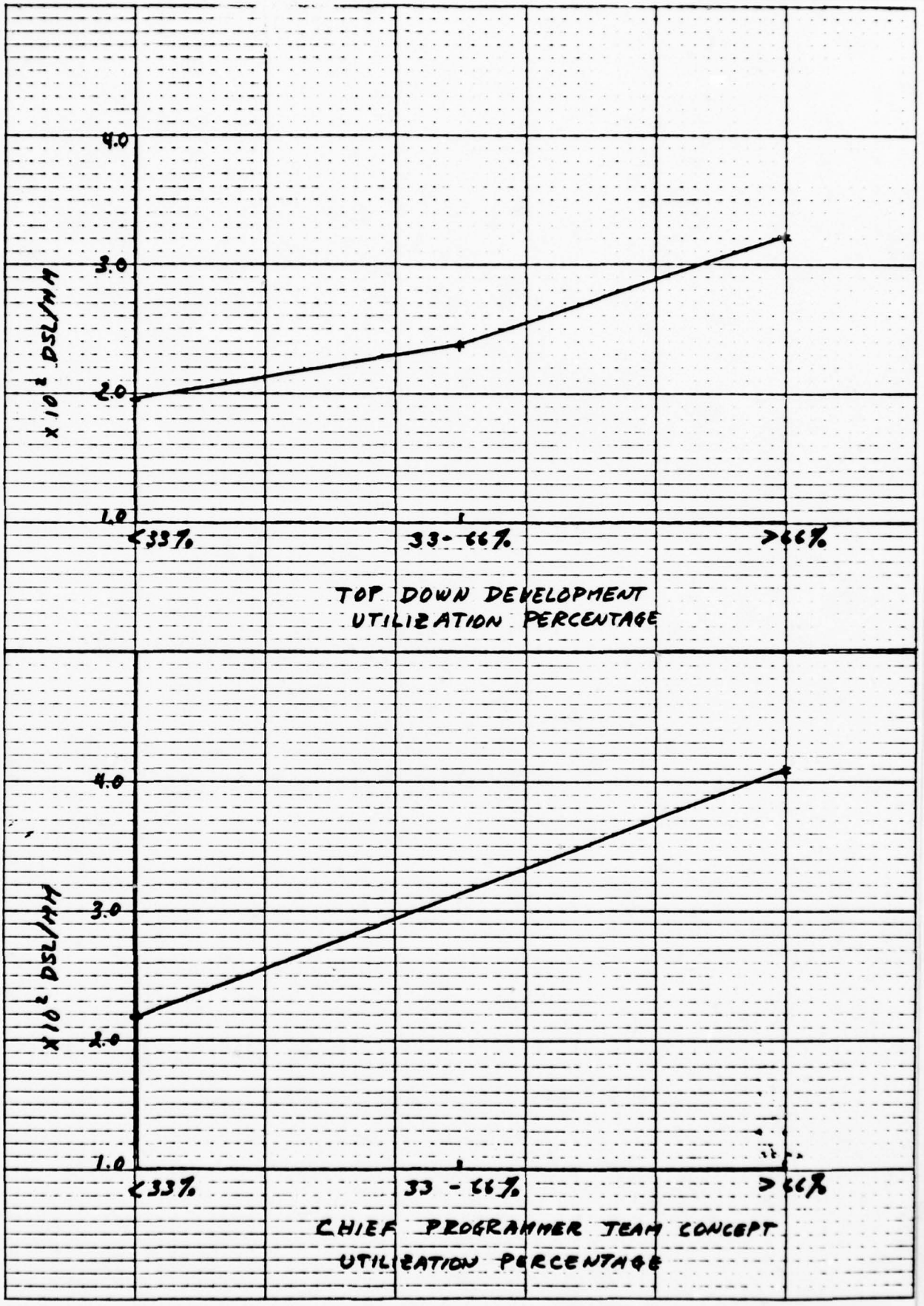
FIGURE II-11 PART A & B



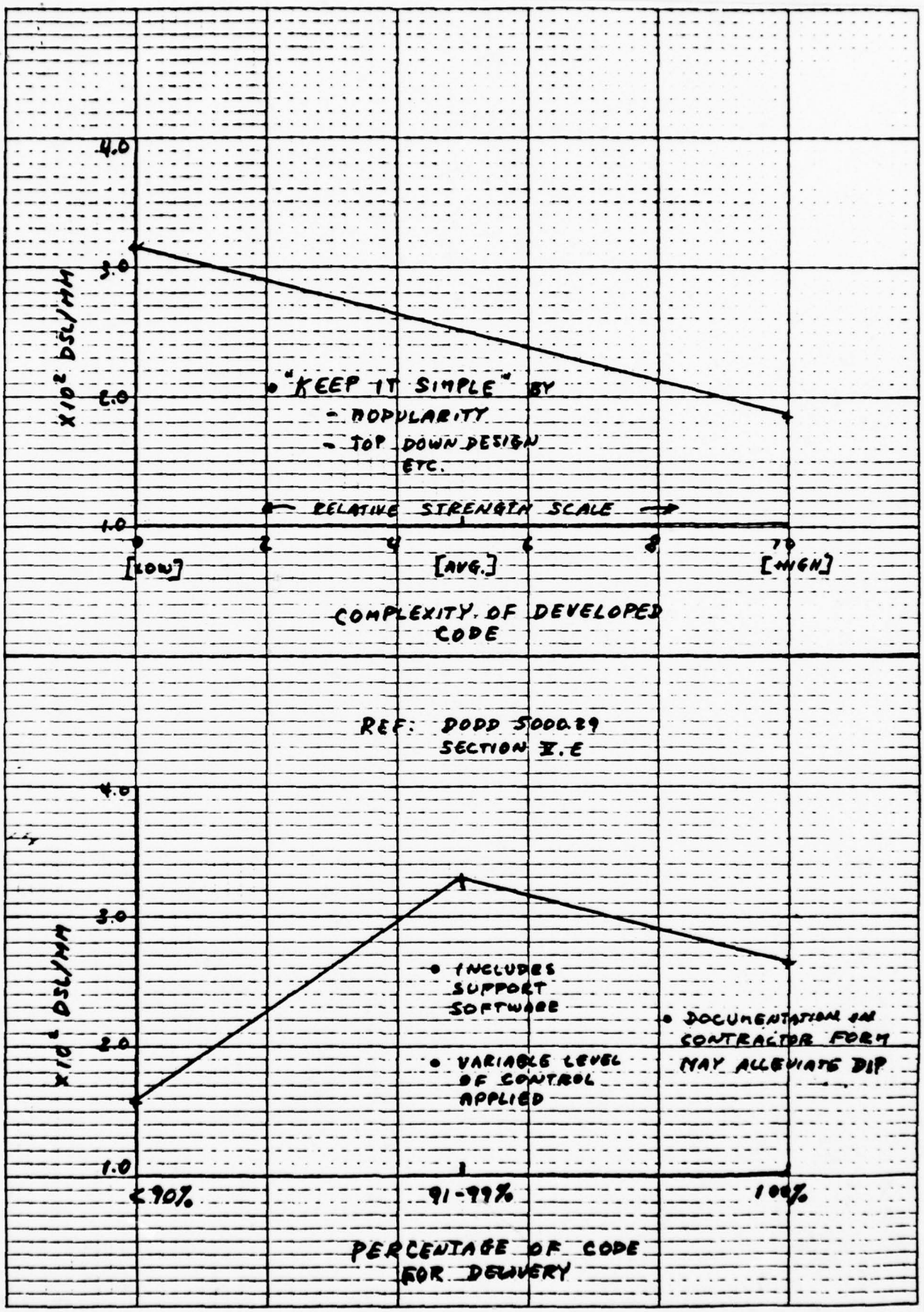
FIGURES II-12 & II-13



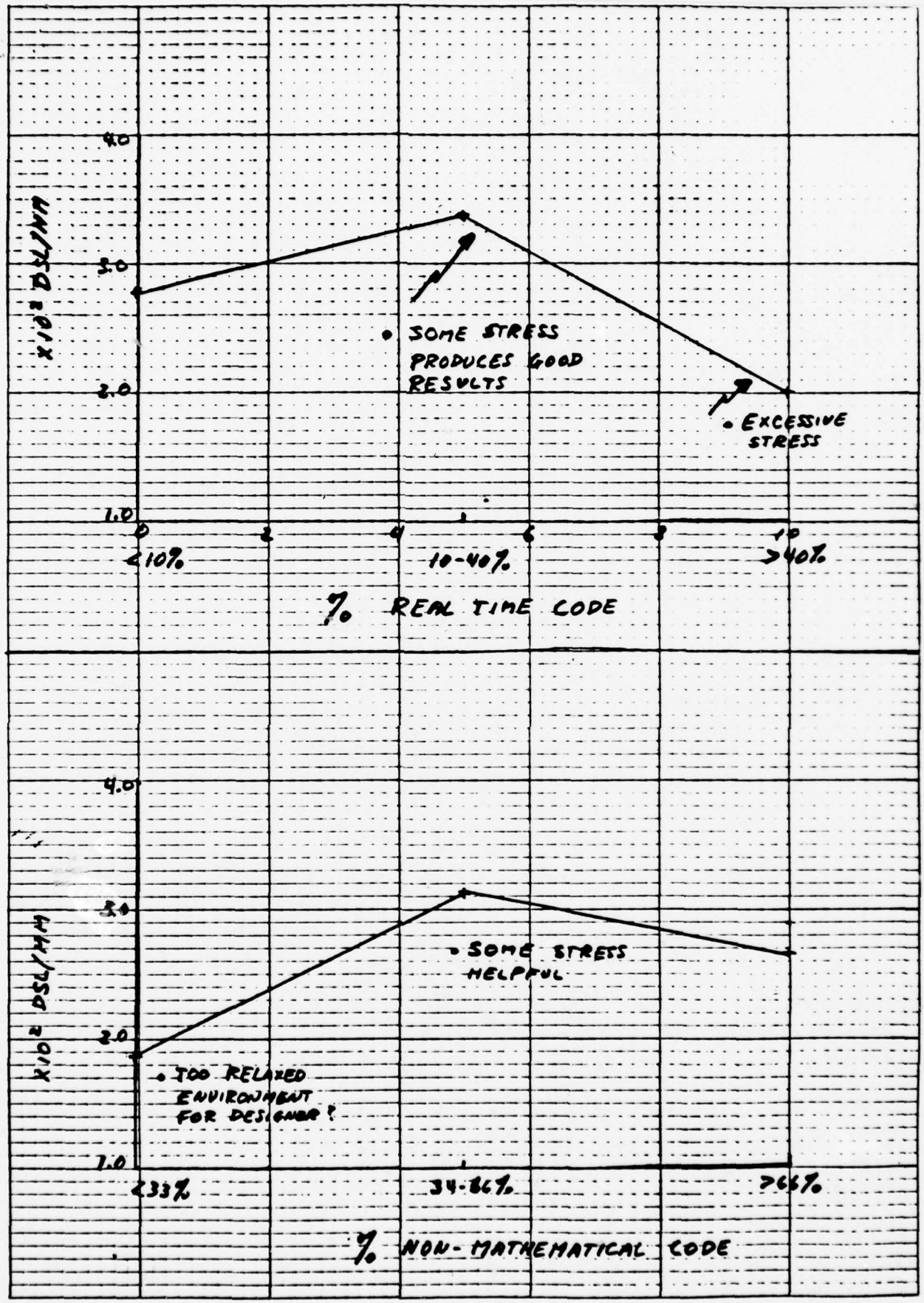
FIGURES II-14 & II-15



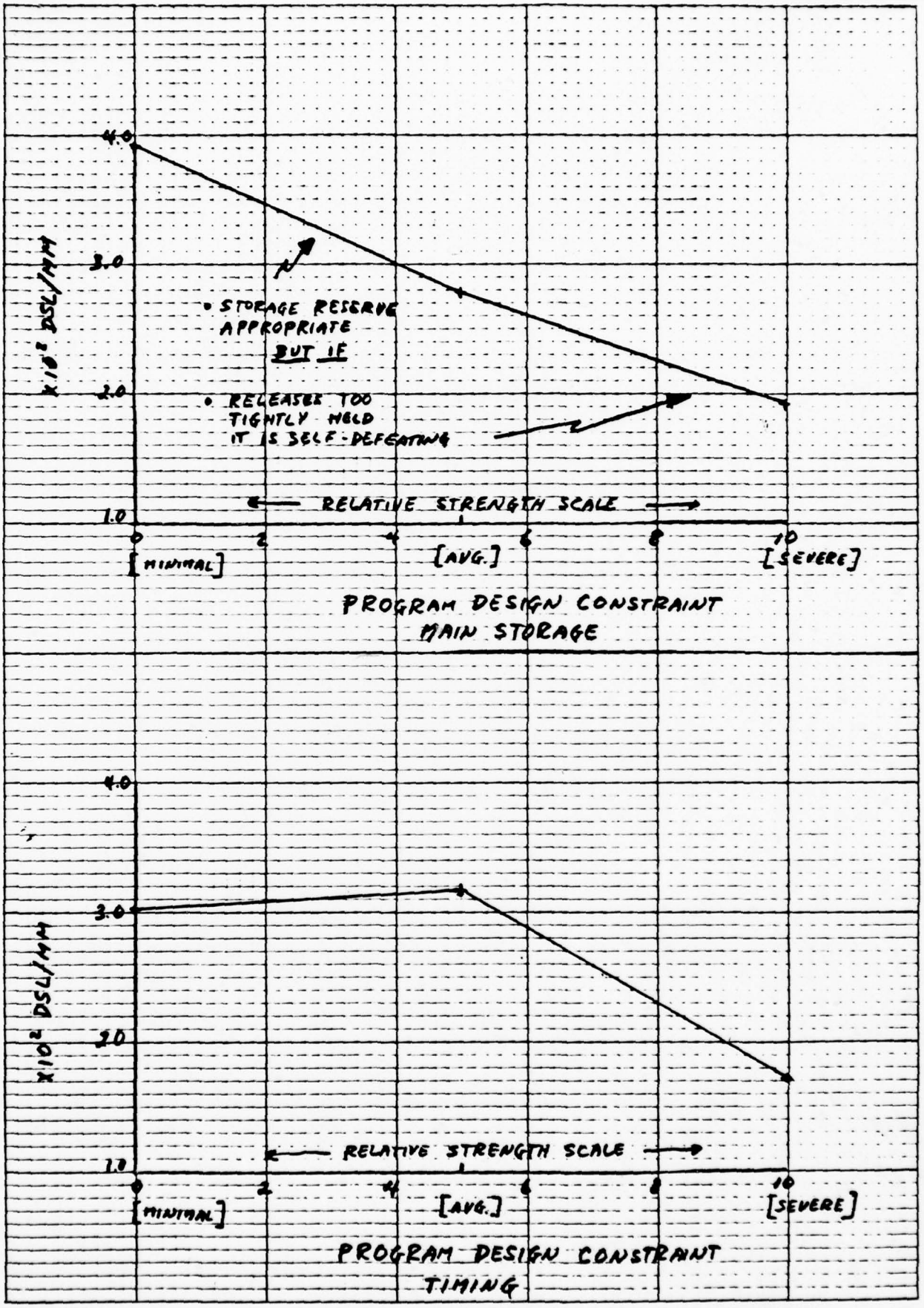
FIGURES II-16 & II-17



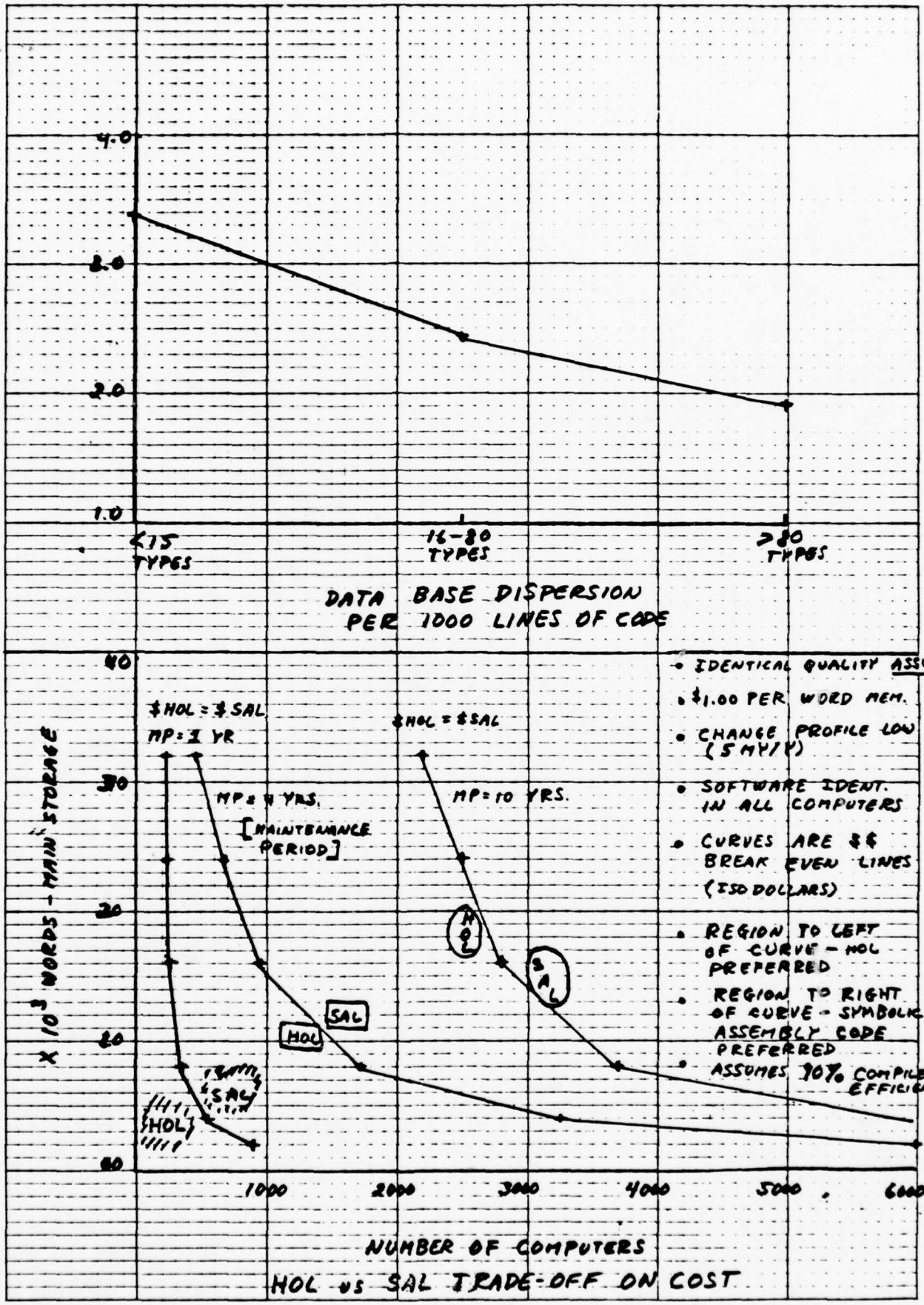
FIGURES II-18 & II-19



FIGURES II-20 & II-21



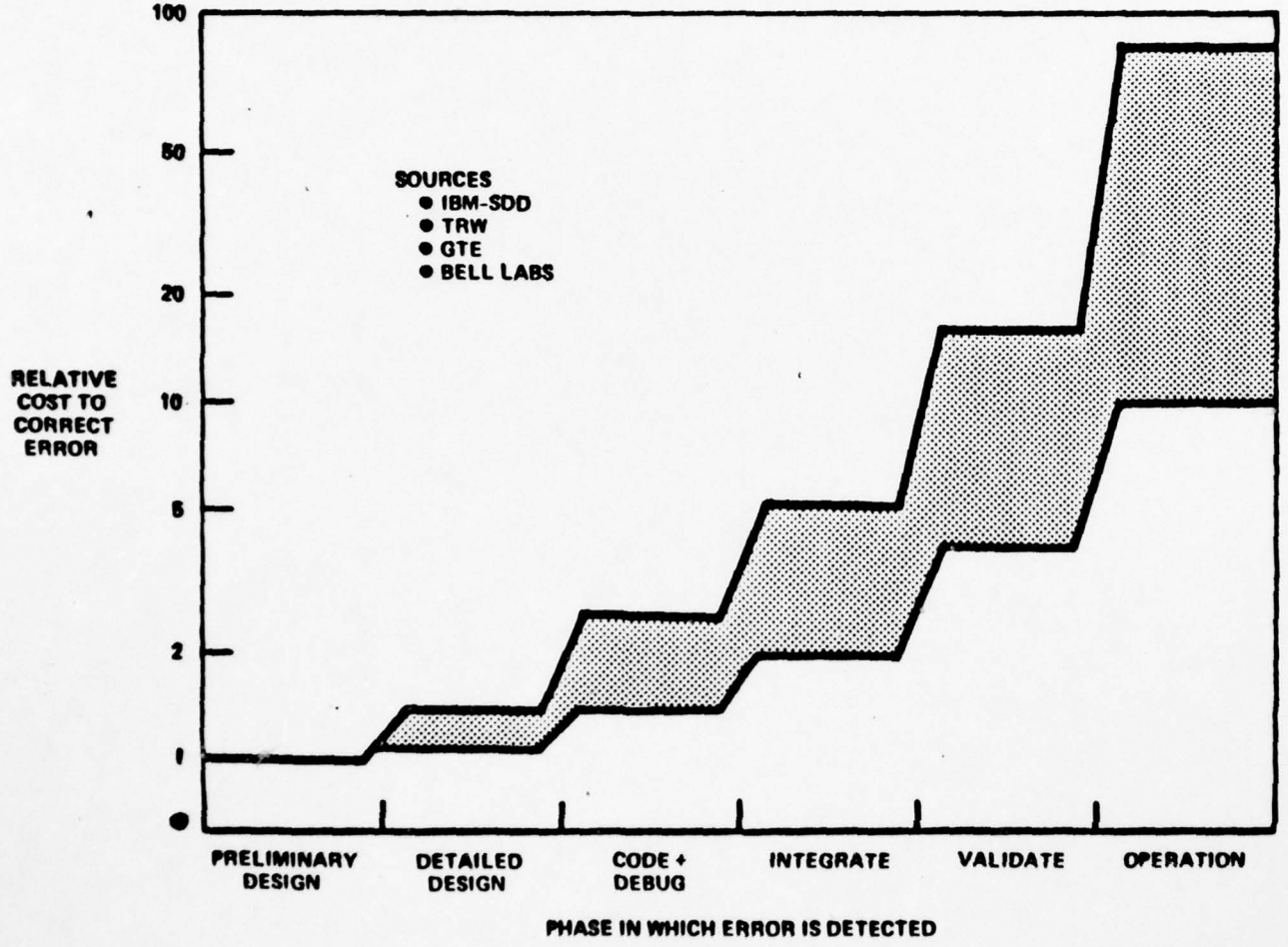
FIGURES II-22 & II-23



FIGURES II-24 & II-25

QUALITY PERSPECTIVE

IT PAYS TO CATCH SOFTWARE ERRORS EARLY



RELATIVE ERROR CORRECTION COSTS
FIGURE II -26

AND WE KNOW WE CAN!!!

PART III

PROGRAM INQUIRY QUESTIONS

PROGRAM INQUIRY QUESTIONS

I. Background Information (contractual)

1. Which of the Modern Program Practices given below are used in your software development project? (Check those that apply.)

___ Program Manager Authority--both technical and administrative responsibility for project.

___ Reviews--formal milestone reviews with customer participation at the end of each phase.

___ Unit Development Folders--capture of working materials for each identified item to facilitate end item development, testing, documentation.

___ Design Discipline and Verification--top down design, formal design representation, completion of design, and deliberate verification of design prior to code.

___ Program Modularity--definitions/restrictions on data interfaces between modules, adherence to parent/child relationships between modules.

___ Naming Conventions--structured names for modules and/or data items.

___ Structured Forms--use of Dijkstra forms as supportable in your programming language.

___ Code Verification--deliberate peer reviews of code for each module.

___ Support Libraries and Facilities--use of automated or proceduralized design, coding, and configuration management aids.

___ Phased Testing--defined and formalized unit, functional, and acceptance testing.

___ Configuration Management/Change Control--creation and control of baselines (requirements, design, implementation) and procedures for problem reporting and resolution.

2. For each practice checked, supply the date of adoption of the practice and the associated software development phase and/or milestone at which it was adopted.

3. For each practice checked, provide a brief rationale which tells why the practice was adopted for your software development project. For each practice checked, indicate the degree of success expected or achieved in the project by its adoption.

4. List the computing hardware (including the host and target machine used by your project and their relationship.

5. List the operating system(s) and compilers/assemblers and utility software used by your project.

6. Indicate the method(s) of access to the hardware and the software. (Check those which apply.)

   ____ Batch

   ____ Remote job entry

   ____ Time sharing

   ____ Stand-alone

7. Describe the availability of hardware/software: the time schedule for computer accessibility and the existence of any restricted or experimental software/hardware used by the project.

8. Indicate the number and type of personnel for your project. (Enter number which applies.)

   ____ Full time, report to Program Manager

   ____ Full time, report outside Program Manager's organization

   ____ Full time, outside contract

   ____ Part time, report to Program Manager

   ____ Part time, report outside Program Manager's organization (e.g., consultants)

   ____ Part time, outside contractor

9. Provide personnel resumes which detail experience and training, both prior to and also during this project development.

10. Indicate the percentage of personnel turnover expected/experienced on your project. Was this turnover planned for? Did it have a detrimental effect on project performance?

11. Characterize your project in terms of magnitude, complexity and software type (e.g., real time, utility, application) performed by the resultant software. When did your project begin?

12. In what phase of the software development is your project currently? (Check only one.)

    ____ Requirements Definition

    ____ Design

    ____ Coding

    ____ Checkout and Unit Testing

    ____ Integration and Testing

    ____ System Testing and Delivery

    ____ In Production (Operation and Maintenance)

II. Software Estimating Guidelines

1. Estimate how much of the total deliverable software is of each of the following types:

    Mathematical Operations ____

    Report Generation ____

    Logic Operations ____

    Signal Processing/Data Reduction ____

    Real Time/Executive/Avionics Interfaces ____

    How many independent programs does this represent?

2. Estimate the total number of deliverable source statements, excluding commentary. (If this is an enhancement or reimplementation, do not include statements which do not have to be recoded.)

3. Is this development a reimplementation of an existing software design? Is this development a conversion of an existing software system?

4. Is this a follow-on contract with your current customer (e.g., major enhancement)?

5. How many designers/programmers support this development?

___ 1-2 ___ 6-10

___ More than 20

___ 3-5 ___ 11-20

6. Is a higher order language being used?

___ not at all ___ exclusively ___ partially

7. Does the source language used provide a macro capability?

___ not at all ___ yes

8. Do you have documentation forms to aid in expression of designs, tests, data structures, etc.?

___ not at all ___ yes

9. Does the computer system used allow for on-line programming activities?

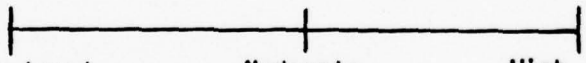
___ not at all ___ yes, code/data entry

___ yes, debugging

10. Does the computer system provide debugging tools?

___ dumps only ___ other (specify)

11. What is the designer/programmer experience with the engineering or technical discipline of application? (Insert ∇.)



Entry level Moderate High

12. What is the actual number of man-months (or man-hours) expended (by phase) on this software development to date? What is the actual dollar cost of this labor expense (by phase) to date?

13. What is the actual amount of CRU's expended (by phase) by this software development to date? What is the actual dollar cost of this machine expense (by phase) to date?

14. What is the milestone schedule? What percent of the total flow time is scheduled for the following phases?

Requirements definition ___

Design ___

Code ____

Checkout ____

Integration and functional test ____

System testing and acceptance ____

15. What percent of the total (estimated) manpower required is planned to be (has been) used in each phase?

III. Indicators of Modern Programming Practice

1. What is the responsibility of the Program Manager?

____ Technical (product quality, reliability)

____ Make task assignments

____ Administrative (budgetary)

____ Evaluate performance of personnel

2. Are formal task assignments provided by the Program Manager to project personnel?

3. Are formal phase reviews scheduled and conducted?

____ Pertinent items identified and available at each review

____ Review objectives specified and understood by participants

____ Results of review followed up

____ Project and customer representatives participate in each review

____ The objectives and procedures for this activity were stated in advance

____ This activity was performed according to these objectives and procedures

4. Is project documentation pertinent?

____ Document schedule exists for review and completion

____ Purpose of each document stated and justified

___ Documents are scheduled so that the project can use each completed document as source material for next phase's activities

___ Each document is reviewed by its intended audience

___ Appropriate user content and language are determined for and contained in each document

___ Project control of documentation so that it "tracks" with requirements/design/implementation changes

___ The objectives and procedures for this activity were stated in advance

___ This activity was performed according to these objectives and procedures

5. Are Unit Development Folders (UDF) used by the project?

___ "Working papers" for each item are captured as they are created

___ Project procedures establish form and content of the UDF's

___ Their contents are utilized for developing other items, completing other tests

___ Project controls the access/use of UDF's

___ The objectives and procedures for this activity were stated in advance

___ This activity was performed according to these objectives and procedures

6. Does the project employ design discipline?

___ Top down design approach specified

___ Formal design analysis and representation techniques used:

___ Static design representation (design trees)

___ Dynamic design representation (transition diagrams)

___ Other (explain)

___ Design refinement methods are used to adapt the abstract design model to the computing environment

___ Design completeness criteria are developed and specified. What are they?

___ The objectives and procedures for this activity were stated in advance

___ This activity was performed according to these objectives and procedures

7. Is the design verified?

___ Peer reviews (structured walkthroughs) of design are conducted

___ The objectives and method of conducting peer reviews are stated in advance

___ Design reachability and connectivity analyses procedurized and used

___ Design modularity analyses procedurized and used

___ Mechanical evaluation method used

___ Project control (compliance methods and verification) over the process of design verification exists

___ The objectives and procedures for this activity were stated in advance

___ This activity was performed according to these objectives and procedures

8. Is the completed design utilized to discipline the code construction process?

___ Standard definition for design and program documentation is established

___ Code construction plan is prepared and used

___ Formal design review involving customer is held prior to start of coding

___ The objectives and procedures for this activity were stated in advance

___ This activity was performed according to these objectives and procedures

9. Is program modularity practiced?

___ Content and format of program specifications are established

___ Modularity criteria specified and adhered to

___ The objectives and procedures for this activity were stated in advance

___ This activity was performed according to these objectives and procedures

10. Are structured forms used in the code?

___ Block structures used

___ Permissible logic statements defined, used, and controlled

___ Project compliance and verification procedures control the use of structured forms

___ The objectives and procedures for this activity were stated in advance

___ This activity was performed according to these objectives and procedures

11. Are formal coding conventions being followed?

___ Syntactical forms defined that are (dis)allowed for each programming language

___ Procedures for accessing external data and handling error conditions

___ Naming conventions for units of code and data variables

___ Project control procedures for code organization and comments

___ The objectives and procedures for this activity were stated in advance

___ This activity was performed according to these objectives and procedures

12. Is the code verifiable?

___ The required testing and examination for each unit of code are documented

___ Peer reviews of the code are procedurized and conducted

___ The objectives and procedures for this activity were stated in advance

___ This activity was performed according to these objectives and procedures

13. Are design aids to support the software development used?

___ Formal design language used in completing the design

___ Manual aids used (specify)

___ Automated aids used (specify)

___ The objectives and procedures for this activity were stated in advance

___ This activity was performed according to these objectives and procedures

14. Are code construction aids to support the software development used?

___ Structured programming practices used to complete the co

___ Manual aids used (specify)

___ Automated aids used (e.g., precompiler) (specify)

___ The objectives and procedures for this activity were stated in advance

___ This activity was performed according to these objectives and procedures

15. Are configuration management aids to support the software development used?

___ Baselined end items are identified and controlled. Indicate at what milestone/phase baseline control was established.

___ Manual aids used (specify)

___ Automated aids used (specify)

___ The objectives and procedures for this activity were stated in advance

___ This activity was performed according to these objectives and procedures

16. Does the project perform unit/integration software testing?

____ Unit/integration testing is defined in a formal test plan

____ There are expected results and pass/fail criteria defined

____ The software correctly implements the design when this testing is complete

____ There is a problem/error reporting system

____ The project uses compliance and verification methods to control this testing phase

____ The objectives and procedures for this activity were stated in advance

____ This activity was performed according to these objectives and procedures

17. Does the project perform functional software testing?

____ An internal review of items is held to judge their quality and completeness prior to functional testing

____ A handover of items into a controlled configuration is made formally by the developers

____ An independent agency performs functional testing

____ The project produces and executes formal test plans and procedures for functional testing

____ There are expected results and pass/fail criteria defined

____ A realistic dress rehearsal of the acceptance test is performed as the final functional test

____ The software correctly satisfies the requirements when this testing is complete

____ There is a problem/error reporting system

____ The project uses compliance and verification methods to control this testing phase

____ The objectives and procedures for this activity were stated in advance

____ This activity was performed according to these objectives and procedures

18. Does the project perform acceptance testing?

___ Acceptance test requirements are part of the project's requirements baseline

___ Formal acceptance test plan and procedures are developed and user concurrence is obtained

___ There are procedures which allow review of the quality and completeness of the deliverables

___ Project and customer are asked if ready to begin acceptance testing

___ There is a formal deliverables baseline and a committed schedule for acceptance testing as a result of a formal review

___ There is an acceptance test report attesting to the satisfactory conclusion or conditional acceptance

___ The report is signed by the customer

___ The objectives and procedures for this activity were stated in advance

___ This activity was performed according to these objectives and procedures

19. Does the project use controlled end item baselines?

___ Project end items by phase are identifiable based on written procedural mechanisms

___ Controlled, review-established requirements, design and implementation baselines exist with written procedures

___ There are mechanisms for updating and distributing established baselines

___ The objectives and procedures for this activity were stated in advance

___ This activity was performed according to these objectives and procedures

20. Does the project utilize a problem reporting system?

___ There are formal procedures for reporting problems, errors, desired improvements

___ There are formal procedures for identifying, processing, and tracking problem reports

___ There are formal procedures for obtaining or distributing problem report status information

___ A file of completed or in progress problem reports exists

___ The objectives and procedures for this activity were stated in advance

___ This activity was performed according to these objectives and procedures

21. Are baseline change control boards used by the project?

___ The board represents project management and customers

___ They have discretionary and budgetary authority to control changes to the baseline

___ They assess proposed changes, and resolve reported problems by assigning action items

___ They prioritize and control the changes to be implemented

___ They authorize baseline updates and distribution

___ The objectives and procedures for this activity were stated in advance

___ This activity was performed according to these objectives and procedures

PART IV

SOFTWARE ESTIMATING GUIDELINES

(CAIG INTEREST ITEM)

SOFTWARE ESTIMATING GUIDELINES

Step 1 -- Determining the Software Type

The estimating task should begin with analysis of the problem to be solved. Generally, the type of software to be developed will be some combination of the following:

- -- Mathematical Operations
- -- Report Generation
- -- Logic Operations
- -- Signal Processing, or Data Reduction
- -- Real Time, or Executive (also, Avionics Interfacing)

In this step, one should estimate how much of the total software will be of each type, and then apply a reasonableness test to whether this distribution is valid. For example, it would be unusual for more than 10-15% of the software to be in the real time category, or more than half to be in the report generation category.

Step 2 -- Estimating the End Product Size

Next, one should estimate for each of the categories determined in Step 1, how much new code must be written. Unless the project has unusually severe requirements for commentary within the code, this set of estimates can be simply in terms of executable statements.

While not executable in the usual sense, statements which define storage areas (Fortran COMMON, for example) should be included in these estimates. Ordinarily, these statements will be a relatively small portion (10% or less) of the total. Care should be taken, however, to recognize situations in which storage definition is a significant portion of the total task -- for example, when the amount of storage available is quite limited and special techniques must be used to fit the data into the space allocated. On the other hand, it should be recognized that storage defining is usually done only once, and then replicated in all of the routines that use the storage.

The estimated number of statements to be coded should include only deliverable code; that number may be significantly smaller than the total number of statements produced, due to the necessity of creating various development aids (test drivers, test data bases, translators, simulators, etc.) to support a project. The adjustment factors of Table IV-1 take into account the creation of such aids. (If a development aid is to be delivered to the customer, it must be considered as a deliverable item in the estimating process, because of the need for testing and documentation of the tool itself).

The results of this step should be compared with the distribution prepared in Step 1, analyzed for reasonableness, and adjusted if necessary before proceeding to Step 3.

Step 3 -- Estimating the Labor Requirements

The preceding steps will have produced a breakout of the development task in terms of new statements that must be coded in each of several categories or software type. In this step, the following multipliers can be applied to estimate the amount of labor required to produce this code.

— Mathematical	≈	6 man-months/1000 statements
— Report	≈	8 man-months/1000 statements
— Logic	≈	12 man-months/1000 statements
— Signal	≈	20 man-months/1000 statements
— Real Time	≈	40 man-months/1000 statements

These factors assume that a "statement" is one fully checked out, tested, and documented statement coded in the selected language. The choice of language can have a significant effect on the development cost, but ordinarily affects only portions of the total task.

Step 4 -- Estimating and Expenditure Distribution

Typically, the final costs of a software development activity will tend to be distributed about as follows:

Task	% of Total Cost
— Requirements Definition	5
— Design and Specification	25
— Code Preparation	10
— Code Checkout	25
— Integration and Test	25
— System Test	10

The distribution shown is a "raw distribution"; that is, it does not take into account such factors as re-implementation, existence of sophisticated debug tools, etc. These factors are accounted for in Table B-1, and are applied in Step 5. Note that the distribution to Requirements Definition and Design and Specification tasks includes documentation; i.e. the user documentation and detailed design specifications are the product of these two tasks.

Further, while the percentages shown here will, in general, be indicative of the manpower allocated on a project, they will not necessarily represent the actual flow time or calendar time scheduled for each task. The adjusted estimates of Step 5 will more closely approach a flow time distribution and could, therefore, be used as a basis for schedule preparation. Documentation is a very apt example of this problem; while the actual preparation of the technical content of a document is correctly represented in the percentages above, typing support and the flow time and effort involved in producing a finished, printed manual is not and should be added to the estimates produced by these guidelines.

In this step, the labor estimates developed in Step 3 should be broken down by task — for each of the software types involved in the problem. The resulting n by 6 matrix (where n is the number of different software types and 6 is the number of activities from Step 4) of individual task estimates will be further adjusted in the next step for the particulars of the project.

Step 5 -- Adjusting the Labor Estimates

Table IV-1 shows multipliers that should be applied to individual estimates to account for various task characteristics. In using this table, it should be noted that the multipliers are task-specific; for example, use of a higher-order language does not affect Requirements Definition or System Test tasks. Other multipliers are cumulative; for example, use of both a higher-order language and macro capability results in a coding cost which is only 27% of the cost using assembly language without macros.

On the subject of macros, care should be used to avoid including in the estimates the effort required to develop any special algorithms (for instance, to satisfy unusual sizing or timing requirements). Such efforts should be estimated separately and their costs added to the basic project costs estimated using these guidelines. Use of the algorithms can be considered equivalent to using macros, however.

Step 6 -- Estimating Computer Time

After the individual task estimates have been adjusted per Step 5, the revised estimates can be summed to arrive at a total labor cost for the project. The final step is to estimate the machine time that will be used during the development activity.

The most widely accepted rule of thumb is that approximately three hours of stand-alone computer time will be spent per man-month.

TABLE II-1: LABOR ESTIMATE ADJUSTMENT FACTORS

		REQUIREMENTS DEFINITION	DESIGN AND SPECIFICATION	CODE PREPARATION	CODE CHECKOUT	INTEGRATION AND TEST	SYSTEM TEST
1. Re-implementation of existing software		0.2	0.2	0.8		0.8	
2. Follow-on contract with current customer		0.7					0.9
3. Number of programmers: (interpolate between values if needed)	1 - 2	0.2	0.5	0.8		0.2	
	6 - 10	1.0	1.0	1.0		1.0	1.0
	more than 20	6.0	3.3	1.2		3.0	3.0
4. Higher-order language (seasoned compiler)			0.3	0.3	0.2		
5. Macro-language — in coding			0.9	0.9	0.9		
— forms for document			0.8			0.8	
6. On-line code/data entry				0.9	0.9		
7. On-line debugging					0.6		
8. Poor (or no) debug tools except dumps					1.4	1.4	
9. Programming experience with engineering/technical discipline of application:	Entry-level	2.0	3.0	1.5			1.5
	Moderate	1.0	1.0	1.0			1.0
	High	0.6	0.5	0.8			0.7

Note: In matrix positions having no entry, the assumed multiplier is 1.0.

PART V

LIST OF REFERENCE DOCUMENTS

- DoD Directive 5000.1, "Major System Acquisitions," January 18, 1977
- DoD Directive 5000.2, "Major System Acquisition Process," January 18, 1977
- *DoD Directive 5000.3, "Test and Evaluation" (DRAFT), Section C.5, July 12, 1977*
- DoD Directive 5000.29, "Management of Computer Resources in Major Defense Systems," April 26, 1976
- DoD Instruction 5000.31, "Interim List of DoD Approved High Order Programming Languages," November 24, 1976
- MIL-STD-52779(AD), "Software Quality Assurance Program Requirements," 5 April 1974 *

* Not Mandatory But Useful!

APPENDIX A

REVELENT SECTIONS OF SELECTED REFERENCES

DoD Directive 5000.29, "Management of Computer Resources in Major Defense Systems," April 26, 1976 (w/o Encl 3)

DoD Directive 5000.31, "Interim List of DoD Approved High Order Programming Language (HOL)," November 24, 1976

April 26, 1976
NUMBER 5000.29

ASD(I&L)

Department of Defense Directive

SUBJECT Management of Computer Resources in Major Defense Systems

References: (a) through (m) are listed in enclosure 4

I. PURPOSE

This Directive establishes policy for the management and control of computer resources during the development, acquisition, deployment and support of major Defense systems.

II. APPLICABILITY AND SCOPE

A. The provisions of this Directive apply to the Office of the Secretary of Defense, the Military Departments, the Organization of the Joint Chiefs of Staff, and the Defense Agencies (hereinafter referred to collectively as "DoD Components").

B. Its provisions encompass major programs of Defense systems acquisition, as designated by the Secretary of Defense (described in section II. of DoD Directive 5000.1, reference (a)). In addition, it provides principles to be applied in the acquisition of Defense systems that do not fall in the "major acquisition category."

C. Excluded from the provisions of this Directive are general purpose, commercially available automatic data processing assets as defined and administered under OMB Circular A-71, DoD Directives 4105.55, 4160.19, and 5100.40 (references (b), (c), (d), and (e)). However, when feasible, the terms, tools, and techniques employed in the general purpose area will be adopted or adapted to support management of computer resources in major Defense systems.

III. DURATION

It is intended that the policies and principles embodied

in this Directive ultimately be assimilated as an integral part of the established process of acquiring major Defense systems. Therefore, the continuing need for this Directive, and all organizational institutions created herein shall be reviewed biannually with a view toward cancellation after 6 years. DoD Directives 5000.1, 5000.2, and 5000.3 (references (a), (g), and (h)) will be modified as appropriate, to reflect this assimilation.

IV. DEFINITIONS

Terms used in this Directive are defined in enclosure 1.

V. POLICY

A. General

1. Annual expenditures by DoD on the design, development, acquisition, management, and operational support of computer resources embedded within, and integral to weapons, communications, command and control, and intelligence sensor systems are measured in the billions of dollars. Unreliability, particularly of software, diminshes DoD mission effectiveness in many major Defense systems.

2. Computer resources in Defense systems must be managed as elements or subsystems of major importance during conceptual, validation, full-scale development, production, deployment, and support phases of the life cycle, with particular emphasis on computer software and its integration with the surrounding hardware.

B. Requirements Validation and Risk Analysis

1. Validation of computer resource requirements, including software, risk analyses, planning, preliminary design, security where applicable (DoD Directive 5200.28, reference (f)) and interface control and integration methodology definition will be conducted during the Concept Formulation and Program Validation phases of Defense system development, prior to Defense Systems Acquisition Review Council (DSARC) II.

2. This analysis must assure conformance of planned computer resources with stated operational requirements.

3. Risk analysis, preliminary design, hardware/software integration methodology, external interface control, security features (DoD Directive 5200.28, reference (f)), and life cycle system planning shall be included in the review.

4. Correctness of software, reliability, integrity, maintainability, ease of modification, and transferability will be major considerations in the initial design.

5. The risk areas, and a plan for their resolution shall be included in the Decision Coordinating Paper (DoD Directive 5000.2, reference (g)).

6. In addition, computer resource requirements will be continuously coordinated and reconciled with system operational requirements throughout system development after DSARC II.

C. Configuration Management of Computer Resources. Defense system computer resources, including both computer hardware and computer software will be specified and treated as configuration items. Baseline implementation guidance for this action is contained in DoD Instruction 5010.21 (reference (i)).

D. Computer Resource Life Cycle Planning. A computer resource plan will be developed prior to DSARC II, and will be maintained throughout the life cycle. The purpose of the plan is to identify

important Defense system computer resources acquisition and life cycle planning factors, both direct and indirect; and to establish specific guidelines to ensure that these factors are adequately considered in the acquisition planning process. Examples of factors to be addressed are the following, as applicable:

1. Responsibilities for integration of computer resources into the total Defense system and the determination of overall system quality and integrity.

2. Personnel requirements for developing and supporting computer resources.

3. Computer programs required to support the development, acquisition, and maintenance of computer equipment and other computer programs.

4. Provisions for the transfer of program management responsibility after initial system operating capability has been achieved; provisions for system/equipment turnover.

E. Support Software Deliverables. Unique support items required to cost effectively develop and maintain the delivered computer resources over the system's life cycle will be specified as deliverable, with DoD acquiring rights to their design and/or use. Examples of such support items are compilers, environmental simulators, documentation aids, test case generators and analyzers, and training aids. The provisions of ASPR, section IX (reference (j)) shall govern the implementation of the policy.

F. Milestone Definition and Attainment Criteria. Specific milestones to manage the life cycle development of computer resources, including computer system and support software will be used to ensure the proper sequence of analysis, design, implementation, integration, test, documentation, operation, maintenance, and modification. These milestones will include specific criteria that measure their attainment.

G. Sofware Language Standardization and Control. DoD approved High Order Programming Languages (HOLs), (reference (k)) will be used to develop Defense system software, unless it is demonstrated that none of the approved HOLs are cost effective or technically practical over the system life cycle. Each DoD approved HOL will be assigned to a designated control agent who will be responsible for such activities as validating compliance of compiler implementations with the standard language specifications, gathering data as to the use of the language, and for disseminating information, compilers, and tools. The designated control agent will also be responsible for assuring language stability except for DoD HOL specifications which already fall within the purview of DoD Manual 4120.3M (reference (m)).

VI. RESPONSIBILITIES

A. In order to oversee and coordinate the accomplishment of policies in this Directive and the incorporation of its principles into the normal Defense system acquisition process, a Management Steering Committee for Embedded Computer Resources is hereby established. This Committee shall operate under the Charter of enclosure 2 for a period not to exceed the life of this Directive.

B. DoD Components will review their existing regulations, specifications, and standards modifying, cancelling, or supplementing them as required to ensure consistency with the policy in this Directive.

C. DoD Components will develop and implement a disciplined approach to the management of software design, engineering, and programming which will ensure the provision of effective software at minimum life cycle cost. To assist in the achievement of this objective, DoD Components will, as a minimum:

1. Prepare and maintain appropriate guidance documents (e.g., guidelines, checklists, handbooks, and descriptive examples) covering requirements definition, development, acquisition, operation, and support issues attendant to computer software in Defense systems. These documents should be available for use as necessary by program managers and their staffs as well as organizations tasked with specific responsibility for developing, acquiring, operating, and supporting the computer resource elements.

2. Establish and/or maintain appropriate education, training, and experience career paths with accompanying career incentives to foster the development and retention of professional computer resource engineers, managers, and technicians.

3. Plan and execute a coordinated research and development program to identify and supply the technological base needed to support the policy, practice, and procedure requirements of this Directive. This coordination will be accomplished using the Technology Coordinating Paper (reference (k)).

VII. EFFECTIVE DATE AND IMPLEMENTATION

This Directive is effective immediately. Five copies of the implementation plan shall be forwarded to the Assistant Secretary of Defense (Installations and Logistics) for approval,

CHARTER OF

DOD MANAGEMENT STEERING COMMITTEE FOR EMBEDDED COMPUTER RESOURCES

I. BACKGROUND

Current annual expenditures by the Department of Defense on the design, development, acquisition, management and operation support of computer resources embedded within and integral to weapons, communications, command and control, and intelligence systems are measured in the billions of dollars. At the same time such computer resources have often presented critical cost and schedule problems during the development and acquisition of new defense systems. Even after system implementation and fielding the software has often proven unreliable. To correct these problems and to improve the management of embedded computer resources in general, a DoD management steering committee is hereby formed. This committee will be responsible for implementing this Directive and will operate under the provisions of this Charter.

II. SCOPE

A. The Management Steering Committee for Embedded Computer Resources (MSC-ECR)[1/] shall implement the provisions of this Directive and issue ensuing policies related to computer resources which are embedded within major Defense weapon, command, control, communications, and intelligence systems.

B. The MSC-ECR activities will not encompass the field of general purpose, commercially available Automatic Data Processing Equipment (ADPE) as defined and administered by references (a), (b), (c), and (d) of this Charter. Working level interfaces will be maintained with the ADPE Community, however, to ensure maximum transferability of ideas and cross-utilization of products.

III. OBJECTIVES

The objectives of the MSC-ECR are fourfold:

A. Improve the management of computer resources embedded in major Defense systems.

1/ Formerly named "Weapon Systems Software Management Steering Committee."

B. Increase visibility of computer resources in overall system acquisitions,

C. Formulate a coordinated DoD Technology Base Program for software basic research, exploratory development, advanced development, and technology demonstrations addressing critical software issues that can be recommended to the Director, Defense Research and Engineering.

D. Guide the assimilation and integration of computer resource policy, practice, procedure, and technology into the normal process of major Defense systems acquisition.

IV. ACTIVITIES

In carrying out the objectives of section III., the MSC-ECR shall:

A. Develop proposed future policies, or changes to existing policies as may be necessary for the acquisition and management of embedded computer resources in major Defense systems, and oversee the implementation of policies stated in this Directive.

B. Advise the Principals of the Defense System Acquisition Review Council on general policy matters and on specific embedded computer resource issues related to major Defense Systems.

C. Provide recommendations and advice to DDR&E on Computer resource R&D technology programs.

D. Provide a focal point for inter- and intra-Service coordination on policy and management issues.

E. Coordinate technology efforts among DoD Components.

F. Review DoD Component activities for compliance with the provisions of this Directive.

V. ORGANIZATION & COMPOSITION

The MSC-ECR shall be composed of an Executive Board and a Management Advisory Board, assisted as necessary by technical panels working in areas of specialized expertise.

A. The Executive Board shall consist of one designated representative from Assistant Secretary of Defense(Installations and Logistics), DDR&E, Director, Telecommunications and Command and Control Systems, Assistant Secretary of Defense (Comptroller), and Assistant Secretary of Defense(Intelligence). The Executive Board will be chaired by ASD(I&L). All decision-making power of the MSC-ECR shall be vested

in the Executive Board; opinions and decisions of the Board will be expressed by the chairman, acting as principal spokesman for the MSC-ECR, and will be based on concurrence of all Board members. If concurrence cannot be achieved, the divergent views will be forwarded with majority and minority reports for resolution by OSD staff principals or the Deputy Secretary of Defense.

B. The Management Advisory Board shall consist of representatives of DoD Components as follows:

Army	3 members
Navy	3 members
Air Force	3 members
Office of the Joint Chiefs of Staff	1 member
Defense Communications Agency	2 members
National Security Agency	2 members
Defense Advanced Research Projects Agency	2 members
TRI-TAC	1 member
Deputy Director (Test and Evaluation), ODDR&E	1 member

RESPONSIBILITIES

Responsibilities pursuant to the provision of this Charter and of this Directive shall be as follows:

A. The Executive Board of the Management Steering Committee shall:

1. Develop policy, or changes to existing policy as may be necessary for the acquisition and management of computer resources in major Defense systems, and oversee their accomplishment.

2. Advise the Principals of the Defense Systems Acquisition Review Council on general policy matters and on specific computer resource issues applicable to DSARC-managed programs.

3. Provide recommendations and advice to the Director Defense Research and Engineering on computer resource R&D technology programs.

4. Review DoD Component activities for compliance with the provisions of this Directive.

5. Assist the Chairman of the OSD Cost Analysis Improvement Group (CAIG) in preparing independent cost estimates for major Defense Systems.

B. The Management Advisory Board of the Management Steering Committee shall, for major Defense Systems:

1. Conduct policy impact assessments and analyses for the Executive Board in both technical and managerial areas relating to computer resources.

2. Serve as focal points for inter- and intra-Service coordination on policy and management issues.

3. Coordinate technology efforts among DoD Components.

4. Review computer resource technology programs for policy consistency, relevancy and impact; advise Executive Board of meaningful technology findings, results, and product developments.

5. Publicize appropriate management and technological developments related to computer resources, throughout DoD and industry.

C. The Management Advisory Board will assist the Executive Board in fulfulling the objectives of the MSC-ECR, and the members will act as focal points for their respective DoD Components in the areas of embedded computer resources.

VII. TECHNICAL PANELS

Adhoc Technical Panels may be formed at the direction of the MSC-ECR to examine problems requiring specialized and detailed expertise. Any panel so formed will be governed by its own Charter, which must be approved by the Executive Board, and will report to the membership of the MSC-ECR. An appropriate Chairman of the Executive Board. Membership on the panel will be determined by the Panel Chairman, and may be drawn from the DoD Components or from industry as appropriate for the task at hand.

VIII. METHOD OF OPERATION

A. The MSC-ECR shall meet quarterly, or upon the call of the Chairman. The agenda will be set by the presiding Chairman, with concurrence by members of the Executive Board.

B. The ASD(I&L), or his designated representative shall act as Executive Secretary to the MSC-ECR, and shall be responsible for preparing the minutes and administering the overall affairs of the committee. Minutes of all meetings shall be distributed no later than 30 calendar days after the subject meeting is adjourned. The ASD(I&L) shall provide administrative support to the MSC-ECR.

IX. DEFINITIONS

The terms defined in the basic Directive shall be applicable to this Charter and the functioning of the MSC-ECR.

X. REFERENCES

A. Office Management Budget Circular A-71, "Responsibilities for the Administration and Management of Automatic Data Processing Activities," March 6, 1965

B. DoD Directive 5100.40, "Responsibilities for the Administration of the DoD Automatic Data Processing Program," August 19, 1975

C. DoD Directive 4105.55, "Selection and Acquisition of Automatic Data Processing Resources," April 5, 1973

D. DoD Directive 4160.19, "Department of Defense Automatic Data Processing Equipment Reutilization Program," April 5, 1973

5000.29 (Encl 3)
Apr 26, 76

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON, D C 20301

29 MAY 1974

MEMORANDUM FOR Assistant Secretaries of the Military Departments (R&D
Director, Defense Advanced Research Projects Agency
Director, Defense Nuclear Agency
Director, Defense Intelligence Agency

SUBJECT: Technology Coordinating Papers

The concept of Technology Coordinating Papers has been evolving for more than four years. In this period, essentially one of trial and error, the concept has been clarified and certain problems associated with the overall implementation have been surfaced. As a result, we are now in a better position to restate the general requirements for TCP's, their utilization, their content, the management of the TCP process, the review and critique process, and the distribution of the coordinated documents. This memorandum provides the overall guidance to DoD personnel involved in preparation or revision of those TCP's either in process or planned for the future, and supersedes prior memoranda of 19 January 1972, 18 August 1972, and 29 March 1973 on this subject.

GENERAL REQUIREMENTS FOR TCP's

The TCP's which have been published are proving invaluable to R&D managers as the best means to provide a bounded overview of selected segments of the DoD technology base. TCP's have served to answer the following questions:

- Are there needless overlaps and duplications?
- Are there vital defense research areas which are underfunded and even missing from the base?
- Are sufficient coordination and interchange taking place among the Services to maximize the return from resources being applied to a given area?

- Are the priorities set correctly; that is, are the spending levels for the various areas consistent with the requirements in those areas?

- Are future weapon system requirements being acknowledged in the more applied work being conducted within the technology base?

- How does the overall program match priorities and mission area deficiencies?

These are the kinds of questions which are of concern to both the DDR&E and the Assistant Secretaries (R&D) & Military R&D Chiefs of the Military Departments who are responsible for overseeing the Service programs. In addition, the Secretary of Defense and the Congress have questions concerning the relative value of the diverse activities contained in the technology base -- questions which can best be answered by showing how the various pieces fit together to make a coherent whole. The TCP's have also served as a device for improving interservice and Defense Agency communications in most technology areas. In some areas, information from the TCP's has also provided the basis for the dissemination of information on technology programs and future needs to the industrial and academic sectors. For these reasons, we shall continue to prepare TCP's in the following technology base program areas:

- Propulsion Technology, Missiles and Space Vehicles
- Medical and Biological Sciences
- Materials Technology
- Structures Technology
- Aircraft Propulsion Technology
- Aeronautical Vehicle Technology
- Human Resources Technology
- Environmental Sciences
- Electronic Devices
- Weapons Technology

- Surface Vehicles
- Electronics Technology (to be initiated in FY 1975)

UTILIZATION OF TCP's

While TCP's have proved an effective mechanism for spotting duplicative, underfunded, or missing programs, they have not generally fulfilled one of the originally intended roles; that of forming a basis for organizing work in specific segments of the technology base where appreciable multi-Service activity or interest exists. Neither have they been optimally utilized by all levels of Service R&D Management as an aid in making decisions on prudent allocation of resources in the various technology areas. Only in some cases have TCP's been used as data bases for the general planning process at the Service staff and systems command levels. In short, it does not appear that middle management in the Services has taken full advantage of the information contained in the TCP documents. This deficiency could be corrected if the TCP's were made a part of the basic documentation for use at all management levels in the preparation of budget and apportionment plans. Additionally, the utilization of TCP information in the preparation of overall investment strategy analyses for specific technology areas would be a valuable adjunct to the planning documents of the individual Services.

CONTENT OF TCP's

The use of a standard format or a standard table of contents for a TCP is not required. The format should be the prerogative and responsibility of the Service/Agency team preparing the TCP. However, if the objectives of the TCP process are to be achieved, these documents should contain at least the following information:

- An examination of the impact of both near term and future military requirements by mission area as they might influence that technology.
- A description of the current and future DoD program in that technology area and the degree to which the program satisfies firm military requirements. This should include a summary of work content, designation of the sponsoring Service or Defense Agency for major tasks, and where these tasks are being performed (in-house or major contractors, by name).

Within this description an explicit discussion of the motivations and relevancy of the 6.1 Research projects should be given. The TCP should also highlight the non-system 6.3 Advanced Technology Demonstration projects with appropriate discussions as to their potential payoff in terms of improved operational capability, cost reduction, or cost avoidance.

- A summary table matrix which correlates technical sub-areas with sponsor, Program Element, and Project number. Because of the problems associated with the distribution of outyear fiscal data, TCP's will be written to contain financial data for only the current and budget years. Data from preceding fiscal years should be selectively included to indicate significant trends. Complete FYDP data will not be shown in the TCP, although anticipated trends in funding levels may be indicated either quantitatively or qualitatively. This restriction is not meant to exclude the consideration of FYDP data in the preparation of a TCP, which can be very useful, or to inhibit publication of FYDP data in an appendix or supplement to the TCP.

- Identification and description (if available) of other DoD programs (i.e., Manufacturing Technology, Component Improvement, etc.) non-DoD programs (NASA, AEC, NSF, etc.) or other major efforts (IR&D), if any, which have a significant impact on the technology area, and an assessment of that impact.

- A short assessment of the technology area itself, including mission area deficiencies, a brief recount of significant historical trends and expected future trends, significant recent accomplishments and (where instructive) significant recent negative results.

No restrictions on the size of TCP's can reasonably be imposed. Some TCP's will be comprised of a single document of perhaps 50-80 pages in length whereas others will be as long as several hundred pages because of the diversity of that technology area. All, however, should contain an Executive Summary (maximum of 20-25 pages) of the salient information in the document.

MANAGEMENT OF TCP PROCESS

- The DD(R&AT) is responsible for the overall implementation of the TCP process.

- The DD(R&AT) is responsible for ensuring that each basic TCP is as concise as possible and that all background information is prepared in a useful format.

- The DD(R&AT) is responsible for determining the rate and frequency of preparation of each TCP. Annual revisions of TCP's will, therefore, not be automatic, but an annual review of each TCP will be made to determine whether to amend, update, rewrite, supplement or make no change.

- It is not required that working drafts or for-comment drafts of TCP's be thoroughly staffed or coordinated at the middle or upper management levels. Forty-five days will be allowed for review of the coordination draft of each TCP. The Assistant Secretaries (R&D) of the Military Departments may, at their discretion, delegate coordination authority. I have delegated the DDR&E coordination authority to the DD(R&AT).

DISTRIBUTION OF TCP's

- The basic TCP documents will not be distributed to industry. They will be selectively distributed to other Federal Agencies such as NASA, CIA, and NSF and to the Congress as appropriate. The DD(R&AT) will determine the appropriateness of TCP distribution outside of DoD.

- Initial and secondary distribution of coordination TCP's will be made through the Defense Documentation Center (DDC). Distribution to other than in-house organizations will require the express approval of DD(R&AT).

- Every effort will be made to distribute TCP information (not TCP's) concerning technology requirements to industry, academic and other non-government personnel. The appropriateness of these distributions will be determined by DD(R&AT).

- Draft and coordinated TCP's will be distributed to appropriate Service laboratories. The appropriateness of these distributions will be determined by the Military Departments.

REVIEWS AND CRITIQUES OF TCP'S

- It shall be the responsibility of the DD(R&AT) to obtain critiques of TCP's as appropriate. The nature of these reviews will vary with the scope and content of the individual TCP. The reviewers may be comprised of professional staff from Federal Contract Research Centers (FCRC's), members of quasi-government institutions such as the National Academy of Sciences (NAS), or selected personnel from private industry or academia.

- When members of private industry or academia are utilized to review TCP's, they will conduct their review in the Pentagon and will not be permitted to take the documents from the building.

- The results of all such reviews will be passed to the Military Departments and appropriate Defense agencies for information and comment if appropriate.

Malcolm R. Currie

REFERENCES

(a) DoD Directive 5000.1, "Acquisition of Major Defense Systems," December 22, 1975
(b) Office of Management and Budget Circular A-71, "Responsibilities for the Administration and Management of Automatic Data Processing Activities," March 6, 1965
(c) DoD Directive 4105.55, "Selection & Acquisition of Automatic Data Processing Resources," May 19, 1972
(d) DoD Directive 4160.19, "Department of Defense Automatic Data Processing Equipment Reutilization Program," April 5, 1973
(e) DoD Directive 5100.40, "Responsibility for the Administration of the DoD Automatic Data Processing Program," August 19, 1975
(f) DoD Directive 5200.28, "Security Requirements for Automatic Data Processing (ADP) Systems," December 18, 1972
(g) DoD Instruction 5000.2, "The Decision Coordinating Paper and the Defense Systems Acquisition Review Council (DSARC)," January 21, 1975
(h) DoD Directive 5000.3, "Test and Evaluation," January 19, 1973
(i) DoD Instruction 5010.21, "Configuration Management Implementation Guidance," August 6, 1968
(j) Armed Services Procurement Regulation, Section IX, Parts 5 and 6
(k) "Interim List of DoD Approved High Order Languages," (To be published)
(l) Director, Defense Research and Engineering Memorandum, "Technology Coordinating Papers," May 29, 1974 (enclosure 3)
(m) Defense Standardization Manual 4120.3M, "Standardization Policies, Procedures and Instructions," January 1972

NUMBER 5000.31

DATE November 24, 197

ASD(I&L)/DDR&E/DTACCS/ASD(C)

Department of Defense Instruction

SUBJECT: Interim List of DoD Approved High Order Programming Languages (

References: (a) DoD Directive 5000.29, "Management of Computer Resources in Major Defense Systems," April 26, 1976
(b) DoD Directive 5000.1, "Acquisition of Major Defense Systems," December 22, 1975
(c) DoD Directive 5100.40, "Responsibility for the Administration of the DoD Automatic Data Processing Program," August 19, 1975

I. PURPOSE

This Instruction specifies the High Order Programming Languages (HOL) which are approved for use in conjunction with reference (a).

II. APPLICABILITY AND SCOPE

A. The provisions of this Instruction apply to the Office of the Secretary of Defense, the Military Departments, the Organization of the Joint Chiefs of Staff, and the Defense Agencies (hereinafter referred to collectively as "DoD Components").

B. Its provisions encompass the selection of HOL for the development of software in major programs of defense systems acquisition as designated by the Secretary of Defense (described in section II of reference (b)), as well as for defense system acquisitions that do not fall in the "major acquisition" category.

C. Excluded from the provisions of this Instruction are:

1. Commercially available software for use with automatic data processing assets as defined and administered under reference (c).

2. Those application or user oriented languages which do not fall within the category of a programming language (e.g., User Requirements Languages, Automatic Test Equipment Languages, Production Control Languages, simulation Languages, and Analyst Aid Languages).

D. The provisions of the Instruction are not to be applied retroactively on any defense systems where a language commitment has already been made, nor is it to be interpreted as prejudicial to language selections occurring before DoD policy formulation.

III. DEFINITION

For purposes of this Instruction a HOL is one which provides compression of computer instructions such that one HOL statement represents many machine language instructions. It is non-problem-specific and is used by programmers to communicate with a computer.

IV. POLICY

A. General

1. This Instruction and DoD Directive 5000.29 (reference (a)) is designed to reduce the proliferation of HOL in defense systems and to ensure control of those HOLs which are approved.

2. DoD approved HOLs will be used to develop defense system software, unless it is demonstrated that none of the approved HOLs are cost effective or technically practical over the system life cycle (reference (a), subsection V.G.). Each DoD Component will designate in its instruction implementing DoD Directive 5000.29 (reference (a)) one office authorized to approve requests for such exceptions. The designated approval authority will maintain appropriate records to support periodic review by the Management Steering Committee for Embedded Computer Resources.

3. Each DoD approved HOL will be assigned to a designated control agent who will be responsible for such activities as assuring language stability and configuration management, validating compliance of compiler implementations with the standard language specifications, gathering data as to the use of the languages, and for disseminating information, compilers, and tools (reference (a) subsection V.G.).

B. Approved High Order Programming Languages

1. The DoD approved High Order Programming Languages, and their defining specification documents are:

a. CMS-2 "CMS-2Y Programmers Reference Manual," M-5049, FDCSSA, San Diego, CA., October 1, 1976: and "CMS-2M Computer Program Performance Specifications," NAVELEX 0967LP-598-2210.

b. SPL-1 "SPL-1 Language Reference Manual," Intermetrics Report No. 172-1.

c. TACPOL CPCEI Part I Specification EL-CG-00043082C Volume 1, April 16, 1971 with ECO Modifications (Appendix 10).

d. JOVIAL Military Standard (MIL-STD) 1588 (USAF) for J3 and MIL-STD-1589 (USAF) for J73.

e. COBOL ANSI X3.23 - 1974.

f. FORTRAN ANSI X3.9 - 1974.

2. The languages CMS-2 and SPL-1 shall be controlled within DoD by the Department of the Navy.

3. The language TACPOL shall be controlled by the Department of the Army.

4. The language JOVIAL shall be controlled by the Department of the Air Force.

5. The languages COBOL and FORTRAN shall be controlled by the Office of the Assistant Secretary of Defense (Comptroller) acting with the National Bureau of Standards and the American National Standards Institute (DoD Directive 5100.40, reference (c)).

V. RESPONSIBILITIES

A. The Management Steering Committee for Embedded Computer Resources, DoD Directive 5000.29 (reference (a)), shall oversee and coordinate the accomplishment of the policies in this Instruction, and advise the principal assistants of the Office of the Secretary of Defense on matters related to this policy.

B. The Military Departments will designate control agents for each HOL under their purview.

C. The HOL control agents so designated by the Military Departments are authorized to update their designated language with compatible extensions and improvements to satisfy validated requirements. Such extensions (e.g. new syntax and/or new

semantics) should not be made more often than once per year. The COBOL and FORTRAN control agents must comply with the current approved version of the American National Standards Institute.

VI. EFFECTIVE DATE

This Instruction is effective immediately.

Assistant Secretary of Defense
(Installations and Logistics)

Assistant Secretary of Defense
(Comptroller)

Director Telecommunications and
Command and Control Systems

Director of Defense Research and
Engineering

APPENDIX B

CONSULTATION AND ASSISTANCE

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